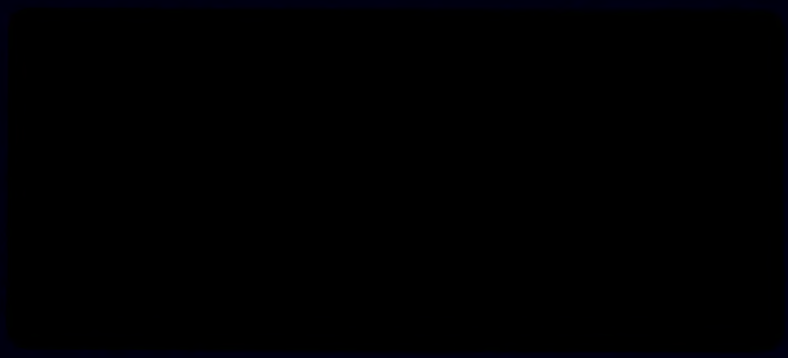
PROTOTYPE OIL SHALE LEASING PROGRAM

FEDERAL TRACT C-a
EXPLORATORY PLAN

Submitted By
GULF OIL CORPORATION
and
STANDARD OIL COMPANY



PROTOTYPE OIL SHALE LEASING PROGRAM

FEDERAL TRACT C-a
EXPLORATORY PLAN

Submitted By
GULF OIL CORPORATION
and
STANDARD OIL COMPANY
(INDIANA)

To The

Oil Shale
Mining Supervisor
United States Geological Survey
Denver, Colorado

May, 1974

PROTOTYPE OIL SHALE LEASING PROGRAM

FEDERAL TRACT C-a
EXPLORATORY PLAN

TABLE OF CONTENTS

Section		Page
1.0	INTRODUCTION	1
2.0	BIOLOGY, SOILS, REVEGETATION AND RECLAMATION	4
2.1	Purpose	4
2.2	Scope	4
2.3	Overview of General Program	6
2.3.1	Soils	6
2.3.2	Vegetation	6
2.3 3	Invertebrates	7
2.3.4	Amphibians and Reptiles	7
2.3.5	Birds	7
2.3.6	Mammals	8
2.3.7	Aquatic Ecosystems	8
2.4	Criteria for Location of Sampling Stations	10
2.4.1	Terrestrial	10
2.4.2	Aquatic	10
2.5	Sampling Methods and Analyses	11
2.5.1	Soils and Overburden	11
2.5.2	Terrestrial Communities	13
2.5.2.1	Vegetation	13
2.5.2.2	Invertebrates	14

		Page
2.5.2.3	Amphibians and Reptiles	15
2.5.2.4	Birds	15
2.5.2.5	Mammals	16
2.5.3	Aquatic Ecosystems	16
2.5.3.1	Plankton	16
2.5.3.2	Periphyton	17
2.5.3.3	Macrophytes	17
2.5.3.4	Benthic Macroinvertebrates	17
2.5.3.5	Fish	17
2.6	Reclamation and Revegetation	18
3.0	METEOROLOGY AND AIR QUALITY	20
3.1	Meteorology Program	20
3.1.1	Equipment Specifications and Location	21
3.1.2	Seasonal Studies	22
3.2	Air-Quality Program	22
4.0	SPECIAL ENVIRONMENTAL STUDIES	24
4.1	Archaeology	24
4.2	Aesthetics - Scenic Values	24
4.3	Seismicity	25
4.4	Noise Measurements	26
4.5	Aerial Photography	26
4.6	Fish and Wildlife Management Plan	26
4.7	Protective Measures	27
5.0	GEOLOGIC EXPLORATION PLAN	28
5.1	Introduction	28
5.2	Geologic Summary, Tract C-a	28

		Page
5.2.1	Structure	28
5.2.2	Stratigraphy	29
5.2.2.1	General	29
5.2.2.2	Oil Shale Section	30
5.2.2.3	Accessory Minerals	31
5.2.3	Conventional Oil and Gas Tests	33
5.3	Exploration Plan	33
5.3.1	Aerial Photography	33
5.3.2	Photogeologic Mapping	34
5.3.3	Surface Geologic Mapping	35
5.3.4	Topographic Mapping	35
5.3.5	Core Hole Program	36
5.3.6	Seismic Program	38
5.3.7	Summary, Geologic Evaluation	39
6.0	HYDROLOGY	40
6.1	Surface Water Monitoring	40
6.1.1	Data Collection and Analysis	41
6.2	Subsurface Hydrology	42
6.2.1	Purpose	43
6.2.2	Data Collection	44
6.2.3	Data Interpretation and Analysis	47
6.2.4	Monitoring Program	48
7.0	MINING	50
7.1	Mining Studies	51
7.1.1	Conventional Mining	51
7.1.1.1	Reserves	51
7.1.1.2	Mine Design	52

		Page
7.1.1.3	Equipment Selection	53
7.1.1.4	Overburden, Waste and Spent Shale Disposal	53
7.1.1.5	Development Plan	54
7.1.2	Potential Future Mining Methods and Equipment	54
7.2	Geotechnical Testwork	55
8.0	PROCESSING	56
9.0	WATER CONTROL AND CORRIDOR PLANNING	57
9.1	Reservoir	57
9.2	Corridor Planning	59
10.0	SUPPORT ROADS AND FACILITIES	62
10.1	General	62
10.2	Primary Roads	63
10.3	Facilities	64

Appendices

A	PROJECT SCHEDULE AND MANPOWER	66
B	METEOROLOGICAL EQUIPMENT AND DATA ANALYSIS	67
C	AIR-QUALITY EQUIPMENT AND DATA ANALYSIS	70
D	CORE HOLE PROGRAM: DRILLING AND OPERATING PLAN	73

Enclosures (in pocket)

1	REGIONAL MAP
2	PRELIMINARY A-GROOVE STRUCTURE AND TOPOGRAPHIC BASE MAP
3	SW-NE HISTOGRAM CROSS-SECTION AND MAIN OIL SHALE INTERVAL ISOPACH MAP
4	SUPPORT ROADS AND FACILITIES

PROTOTYPE OIL SHALE LEASING PROGRAM

FEDERAL TRACT C-a
EXPLORATORY PLAN

1.0 INTRODUCTION

In compliance with Section 10(d) of the oil shale lease, Gulf Oil Corporation and Standard Oil Company (Indiana) hereby submit for approval an Exploratory Plan which specifies the data-gathering program and office studies proposed for Federal Tract C-a. Prior to such approval, Gulf and Standard will file a bond in such an amount as the Mining Supervisor shall require for conduct of the Exploratory Plan.

The Exploratory Plan details Gulf and Standard's plans for obtaining environmental baseline data, establishing monitoring programs, and collecting resource data needed to make the office studies which will culminate in selection of mining and processing steps for the Detailed Development Plan. Based on field data to be obtained mostly in 1974, extensive planning and evaluation studies of the various mining and processing alternatives will be made in 1975. Plans are to submit the Detailed Development Plan by early 1976.

The Exploratory Plan may be supplemented or modified as indicated by analysis of the data as it is gathered, but such changes in scope will not be made without prior approval of the Mining Supervisor in conformity with the lease regulations.

The baseline data will be the basis for determining environmental effects as the lease is developed. It is Gulf and Standard's intent not only to measure baseline conditions for 2 years as stipulated by lease

requirements, but also to monitor selected parameters continuously until all lease activities cease.

The environmental portion of this plan will constitute a major part of the overall effort during the next two to three years. Meteorology, air quality, and certain other minor tasks can be fairly well defined at this time and initiated almost immediately after approval. Biological studies, revegetation experiments, and archaeological surveys necessarily require a two-phase approach: Phase I to define the exact problems to be solved and the methods and parameters needed to solve them; Phase II to implement the recommendations made in Phase I.

In accordance with the lease regulations, no portion of the field data-gathering program, presented herein, is considered to be a part of the Detailed Development Plan itself. Field experimental work, to the extent of digging test pits or shafts for mine development or the erection and operation of pilot or prototype retort plants, is not presently contemplated by Gulf and Standard during the exploratory period. Development work of this nature, if required, would more likely be a part of the Detailed Development Plan.

Map enclosures 2 and 4 (found in the pocket at the back of this report) show locations of proposed drill holes, baseline measurement stations, power lines and access roads both on and off Tract C-a. In cases where these locations are on public lands that are not a part of Tract C-a, special land use permits will be obtained as needed from the Bureau of Land Management.

The projected employment total is low, indicating that socio-economic effects from the Exploratory Plan work will not be significant.

A maximum of about 100 people will be employed at the lease tract, consisting primarily of drilling crew personnel during the peak of the 1974 drilling program. Only a few people will be employed in the field after the drilling programs cease; they will be seasonally-varying personnel making biological inventories plus a small year-round staff conducting the monitoring programs.

Gulf and Standard will keep local, state and federal planning bodies fully advised of the larger future employment projections associated with the construction and operation of the initial commercial installation. Such advisement will be made as soon as possible after Gulf and Standard have developed the projections which probably will be no sooner than mid-1975. The actual rise in employment would not begin until after approval has been obtained for the Detailed Development Plan. This should be early to mid-1976.

Section

Table of Contents

Section		Page
2.0	BIOLOGY, SOILS, REVEGETATION AND RECLAMATION	4
2.1	Purpose	4
2.2	Scope	4
2.3	Overview of General Program	6
2.3.1	Soils	6
2.3.2	Vegetation	6
2.3.3	Invertebrates	7
2.3.4	Amphibians and Reptiles	7
2.3.5	Birds	7
2.3.6	Mammals	8
2.3.7	Aquatic Ecosystems	8
2.4	Criteria for Location of Sampling Stations	10
2.4.1	Terrestrial	10
2.4.2	Aquatic	10
2.5	Sampling Methods and Analyses	11
2.5.1	Soils and Overburden	11
2.5.2	Terrestrial Communities	13
2.5.2.1	Vegetation	13
2.5.2.2	Invertebrates	14
2.5.2.3	Amphibians and Reptiles	15
2.5.2.4	Birds	15
2.5.2.5	Mammals	16

		Page
2.5.3	Aquatic Ecosystems	16
2.5.3.1	Plankton	16
2.5.3.2	Periphyton	17
2.5.3.3	Macrophytes	17
2.5.3.4	Benthic Macroinvertebrates	17
2.5.3.5	Fish	17
2.6	Reclamation and Revegetation	18

2.0 BIOLOGY, SOILS, REVEGETATION AND RECLAMATION

The studies described in this section cover the biology of soil, air and water. Since such data not only are needed for the baseline inventory program to describe present conditions, but also are partially necessary for development of a revegetation and reclamation plan, these latter have been included in the section.

2.1 PURPOSE

The reason for these studies is to: (a) conduct a comprehensive 24-month inventory of the Tract C-a environment and the surrounding area within a five-mile radius or as indicated otherwise; (b) provide a baseline to evaluate changes in community structure associated with oil shale development; (c) refine long-term monitoring programs using the foundation laid by this baseline inventory; (d) determine if there are any rare or endangered species that will be affected by oil shale development; (e) develop the information necessary for a fish and wildlife management program to be applied in and around Tract C-a; (f) describe the condition of the ecosystem prior to the mining operations. This description will form the basis for making decisions to insure that affected lands will be reclaimed and revegetated to a usable and productive condition consistent with or equal to pre-existing land uses in the area and will be compatible with existing, adjacent areas.

2.2 SCOPE

The baseline inventory program will be divided into two distinct phases. Phase I will be approximately three months in duration and will

consist of three key elements: (a) literature review, (b) interviews, and (c) specific site studies. These elements are essential to define exactly the experimental and reference areas as well as the scientific methods most appropriate for the biological systems in these areas.

Reviews of existing literature will include, but not be limited to, the following reports: Final Environmental Impact Statement: Prototype Oil Shale Leasing Program; Colorado Department of Natural Resources and Bureau of Land Management reports; Thorne Ecological Institute Report: An Environmental Reconnaissance of the Piceance Creek Basin; Colorado State University Report of Surface Rehabilitation of Land Disturbances Resulting from Oil Shale Development; the Institute of Ecology's commentary on the Department of the Interior's EIS; and any others pertinent to this project.

Interviews will be conducted with appropriate federal and state scientists to establish further the base of existing information.

Site studies will be made as a necessary prerequisite to determining the location of specific sampling areas and to determine proper sampling parameters for the conduct of Phase II of the baseline inventory program.

Phase II will begin in the summer of 1974 and extend into 1976. It will involve the bi-monthly gathering of data, data analyses and preparation of reports. The inventory program will collect data bearing on species diversity, on community structure, function and productivity, on community stability and successional relationships, and on population dynamics of Tract C-a and the surrounding region. Particular attention will be given to those species of plants and animals that are sensitive

indicators of ecological stress (such as herbaceous plants, beetles, raptors, voles, etc.).

2.3 OVERVIEW OF GENERAL PROGRAM

2.3.1 SOILS

Soil survey investigations conducted during the study period will follow standard Soil Conservation Service approaches and will be made to develop a soil map showing soil profiles and composition. Information important to the area from the standpoint of vegetation production, habitat enhancement, and erosion potential will be included in the report.

Soil and overburden samples will be collected and analyzed for physical and chemical properties and classified by type. In addition, slope angle information will be taken to assist the calculation of moisture retention properties.

2.3.2 VEGETATION

A detailed description will be completed for all present community types found within and in the vicinity of Tract C-a. Estimates of net primary productivity of the communities will be made to provide information about food chains and biomass cycling. Species diversity and alpha and beta diversity indices will be made.

Community composition, basal area cover, relative frequency, DBH measurement, relative abundance, seasonal variation, and age will be measured. Appropriate microclimatic data from each major plant community will be collected.

Disjunct and unique populations, rare or endangered species, and species of aesthetic, recreational, or economical value will be identified and their abundance and distributions described.

Based on observations made during the field programs, the literature review, and any other information, biotic successional processes will be described. A projection of their normal sequence and interrupted sequence in the areas of concern will be made.

2.3.3 INVERTEBRATES

A survey of species diversity and temporal fluctuations in population densities will be made of surface and subsurface inhabiting arthropods. An assessment will be made of the importance of these to food chain relationships and community dynamics.

2.3.4 AMPHIBIANS AND REPTILES

Literature will be reviewed and field studies will be performed to determine the presence of amphibian and reptilian species. Rare, unique, or endangered status will be ascertained. Particular attention will be given to the Short-horned Lizard (*Phrynosoma douglassi*) and to the Sagebrush Lizard (*Sceloporus graciosus*) which are sensitive to environmental stress.

2.3.5 BIRDS

Surveys will be made on and about Tract C-a to identify species, seasonal occurrence, abundance, and nesting of birds. Particular attention will be directed toward raptor and game species.

2.3.6 MAMMALS

Studies of the mammalian fauna will include:

(a) Mark and recapture surveys to determine species diversity, population densities, and distributions of small mammals. Emphasis will be placed upon species such as voles that are indicators of environmental stress. Stomach samples will be randomly collected and analyzed to determine niche relationships. An effort will be made to determine whether rare and endangered species (Black-footed Ferret, Spotted Bat, etc.) are present and how they would be affected by oil shale development.

(b) Investigation of large mammal populations will be made by direct observations of individuals, tracks, scat, evidence of browsing, etc. Particular attention will be paid to the numbers and feeding habits of deer, elk, and wild horses residing in or migrating through the areas of concern.

2.3.7 AQUATIC ECOSYSTEMS

Aquatic studies will concentrate on defining kinds of aquatic habitats that will be affected by oil shale development on and about Tract C-a. Species composition, productivity of these systems and importance to man, and relative uniqueness of the habitats or species will be determined. Such aspects are related to potential or actual project impacts. Studies will include a continuation of literature surveys and interviews, as well as collection and analysis of field data.. Since most of the viable aquatic ecosystem occurs off Tract C-a, and because on-tract streams are intermittent, the

majority of the following studies will take place off the tract. Specific research in the inventory program will involve the following areas:

(a) Habitat types will be surveyed to provide a basis for measuring changes due to water flow and water quality.

(b) The presence and abundance of aquatic macrophyte communities will be determined when appropriate, random transects will be used along stream banks, and species composition and estimates of percent area covered will be made.

(c) Although plankton are not normally an important part of the food chain in high altitude lotic habitats, their abundance and composition will be measured by random samples, if found.

(d) The abundance and species composition of periphyton will be assessed by scraping a known area of rock or by following growth on artificial substrates. Because periphyton stay in one location, they are more important in lotic systems than plankton and may show a clinal change from a discharge point. The biomass per unit area, an index to their importance as a primary producer in the systems, will be determined.

(e) Data to calculate species diversity indices and to assess stress conditions relating to benthos will be collected. Benthos may be expected to be the main source of transfer of energy from periphyton and detritus to fish populations in the streams.

(f) Field studies of fish, the highest level carnivore in an aquatic habitat, will determine species composition, relative importance of each species to its community, identi-

fication of species which are likely to be the most sensitive to changes in physical or chemical conditions of their environment, productivity of the community, existence of rare or endangered species and species of economic, aesthetic or recreational value to man. Creel census programs to determine fishing pressure and success will be used in conjunction with other studies.

2.4 CRITERIA FOR LOCATION OF SAMPLING STATIONS

Following are general scientific guidelines establishing criteria for the location of sampling stations. Location and number of specific sampling stations and traverses are necessarily dependent upon completion of Phase I studies.

2.4.1 TERRESTRIAL

The locations of sampling stations within Tract C-a, on immediately adjacent areas (perimeter), and on surrounding land within the five-mile radius will be determined so as to provide data from comparable biotic communities. In addition, any major biotic community found within the five-mile radius, but not on the lease, will be monitored.

In order to monitor natural variation within each major community, specific sampling sites will be located where there is the most homogeneity of vegetation.

2.4.2 AQUATIC

The general locations of aquatic sampling stations will be determined so as to provide data from comparable habitats and communities

directly affected, indirectly affected, and unaffected by oil shale development on Tract C-a.

Specific locations, to include Yellow Creek near its confluence with the White River, will be chosen to represent appropriate type habitats.

2.5 SAMPLING METHODS AND ANALYSES

The sampling methods described in the following paragraphs are general approaches based on limited site-specific information. Therefore, they should be considered as being tentative and subject to modification as is deemed necessary during Phase I.

2.5.1 SOILS AND OVERBURDEN

All available information pertaining to the soils of Tract C-a and its environs will be compiled and a survey will be made of soil types found on these lands. The soils report will include verbal descriptions and a map of the kind contained in standard Soil Conservation Service soil survey reports. Comments indicating the suitability of the soils for topdressing of spoils will be included.

Drill cuttings of topsoil and overburden from various localities on lands to be affected by Tract C-a oil shale development will be obtained. Samples representative of topsoil and each kind of subsurface stratum will be subjected to the following laboratory analyses:

Arsenic	Mercury
Sodium	Molybdenum
Potassium	Nickel
Calcium	Vanadium
Magnesium	Zinc

Sulfur	Chloride
Nitrogen	Organic matter
Boron	Iron
Seleium	Water soluble sodium
Cadmium	Water soluble potassium
Chromium	Water soluble magnesium
Cobalt	Water soluble calcium
Copper	Water soluble iron
Fluorine	Nitrate
Lead	Available phosphorus
Total exchangeable cations	Exchangeable sodium
Total water soluble salts	pH
Moisture	Particle size distribution and classification

Based upon results of these analyses and climatological data, a written report will be prepared that will include the following:

(a) Recommendations where overburden materials, if any, should be buried because they are toxic or inhibitory to plant growth.

(b) Recommendations for fertilization and mulching.

(c) Recommendations on which species of plants can and should be planted assuming that the land will be used ultimately for livestock grazing and wildlife habitat. If a different land use is projected, the species of plants recommended will be changed accordingly.

Trace elements will be monitored to determine natural background concentrations. Specific elements which will be monitored (if in concentrations high enough to be significant) are: antimony, arsenic, boron, cadmium, chromium, cobalt, copper, fluorine, iron, lead, magnesium, magnesium, manganese, mercury, molybdenum, nickel, selenium, sodium, vanadium and zinc. Other elements will be monitored if their concentrations are found to be significantly high.

2.5.2 TERRESTRIAL COMMUNITIES

2.5.2.1 VEGETATION

Within and surrounding Tract C-a, three types of vegetative growth forms can be recognized: herbaceous, woody shrubs and trees. Herbaceous vegetation includes grasses, sedges and forbs. Shrubs may be defined as woody plants less than three meters in height and having a diameter at breast height (DBH) less than five centimeters. Trees may be defined as woody species taller than three m and with a DBH greater than five cm.

Surrounding the tract and within it there is a vegetative mosaic of herbaceous and woody shrubs. This mosaic will be broken down into units of maximum homogeneity and each unit studied independently by community and strata. Homogeneity within each type will be the prime consideration in determining the number of samples that are adequate. Therefore, the size of quadrats, or transects, or points to be utilized at any sampling site should be determined in the field during Phase I by inspection and use of a species area curve. This curve can provide a semi-quantitative determination of the quadrat size necessary for an adequate sample.

Each vegetative type area to be sampled will be divided into areas of appropriate size, these will be numbered, and those to be sampled will be determined by use of a random number table.

Within each of the three general areas (lease, perimeter, and five-mile radius), three permanent quadrats each, will be established for herbaceous and woody shrub communities. For a pinon-juniper community,

the point-quarter analysis will be used. Where there are definite strata, a nested quadrat, approximately 1 m x 1 m plot inside a 4 m x 4 m plot may be appropriate to sample herbaceous vegetation and woody shrubs respectively.

Basal cover, that portion of the ground occupied by vegetation, will be expressed as a percentage of total area. Frequency, diversity, dominance and importance values will also be calculated.

Seasonal production (net productivity) will be estimated quantitatively at each station during the spring and summer seasons and end-of-season production will be estimated in the fall.

Plant specimens will be collected in the field during each season to establish a plant list for all seasons and to assure that important plant species will be collected in the phenological condition required for proper identification. Examples of each species will be preserved for voucher specimens.

Qualitative estimates of epiphyte infestations will be evaluated by visual observation.

2.5.2.2 INVERTEBRATES

A survey will be conducted to evaluate the diversity of terrestrial invertebrates on the site and their relative seasonal abundance. Standard sweepnet and aspirator procedures will be utilized for sampling aerial and vegetative habitats while litter samples will be used to monitor soil invertebrates. Particular attention will be given to population size and density of such forms as beetles that are indicator species of ecological stress.

2.5.2.3 AMPHIBIANS AND REPTILES

To evaluate the presence of amphibians and reptiles, survey routes will be established along drainages and at sampling localities. These will be surveyed during the regular bi-monthly monitoring periods. In addition, more frequent and intensive surveys will be made during the spring and early summer breeding seasons. During these times of the year, all bodies of water (temporary and otherwise) will be checked for nocturnal breeding of amphibians. Records will be kept of numbers and species encountered.

2.5.2.4 BIRDS

Permanent transects will be established within each vegetation community being sampled. These transects will represent the baseline for the strip census. The strip census will be conducted to establish species diversity, distribution and population density by season, and area usage. A description of the feeding habits, movements and migratory patterns will be conducted for the more important indigenous species.

Species which are deemed to be rare or endangered, or to be of recreational, aesthetic, or economic value to man will be determined.

Special attention will be given to resident and migratory raptors, including the Bald Eagle, Golden Eagle, American Peregrine Falcon, Arctic Peregrine Falcon, etc., that may be affected by oil shale development. All areas to be affected will be searched for nesting sites and breeding areas at appropriate times of the year. The number of nesting pairs will be recorded. Any activities of these raptors in the sampling areas will be noted.

2.5.2.5 MAMMALS

Small mammal populations will be evaluated by live trapping in each sampling community, utilizing a mark-recapture technique. Trap grid sizes will be altered to accommodate the conditions and total area available within any sampling station under investigation. All areas to be affected by Tract C-a oil shale development will be searched to determine the presence of prairie dog towns or other potential Black-footed Ferret habitats.

Numbers of large mammals, including deer, elk, and wild horses, will be estimated by census and aerial counting. Migratory routes will be mapped within the three sampling areas (Tract C-a, perimeter and five-mile radius) in order to determine whether drift fences will be effective and, if so, where they will be needed to direct big game movements around or away from oil shale development areas.

2.5.3 AQUATIC ECOSYSTEMS

The biotic sampling program will concentrate on plankton, periphyton, aquatic macrophytes, benthic macroinvertebrates and fish. The following sections provide descriptions of sampling techniques and appropriate analyses.

2.5.3.1 PLANKTON

Replicate plankton samples will be collected at all appropriate sampling stations. Samples will be preserved with Lugols solution. Phytoplankton samples will be stored in a darkened room to prevent cells from fading.

2.5.3.2 PERIPHYTON

Rock scrapings as well as artificial substrate samples will be used to collect periphyton. Styrofoam samplers will be employed at selected stations with retrievals at appropriate intervals.

2.5.3.3 MACROPHYTES

Aquatic macrophyte sampling will be limited to qualitative collections to determine species composition and relative abundance of submergent and emergent macrophytes on the site. Sampling efforts will be opportunistic, according to the phenology of the particular species sampled.

2.5.3.4 BENTHIC MACROINVERTIBRATES

Community structure of benthic macroinvertebrates will be determined through use of sampling dredges. Triplicate samples will be collected initially and later revised if necessary. Sampling points within each station will be chosen to represent a variety of habitat types. Qualitative samples will be collected along the edges of pools and banks. Drift organisms will be sampled with drift nets for 12-hour periods during spring and summer months. Species diversity will be calculated.

2.5.3.5 FISH

Fish sampling will be conducted with appropriate equipment. Creel census studies will be made where appropriate to evaluate the usage and importance of drainages for recreational fishing. Fishing

efforts at each station will be kept consistent so that catch-per-unit effort indices can be used to evaluate seasonal changes in relative abundance of species.

Length and weight will be recorded on all fish. Scale or spine samples will be taken from selected sport and forage species. Condition factors will be calculated in addition to growth histories to further characterize the overall suitability of the aquatic environment. Additionally, the occurrence of any external parasites will be noted.

Evaluation of major trophic relationships of selected forage and sport fishes will be made through food habit studies.

2.6 REVEGETATION AND RECLAMATION

A major reason for many of the preceding terrestrial vegetation and soils studies is to establish an objective basis on which to formulate reclamation programs to return the area to livestock grazing and wildlife habitat.

There are a number of possible ways to accomplish this intended aim. Spent shale could be made suitable for revegetation, topsoil and overburden materials could be identified and set aside for covering spent shale, or some combination of the two could be utilized. The various possibilities will be rigorously explored.

Research on revegetation of Tract C-a will be conducted during the Exploratory Phase. Pertinent literature will be critically reviewed, established plots will be evaluated on site, and available academic, gov-

ernment and industry experts will be consulted. Growth chamber and plot studies will be planned from the results of the initial study to determine plant-growth characteristics of spent shale, critical depths of overburden, possible revegetation species, and water and fertilizer requirements.

Table of Contents

Section		Page
3.0	METEOROLOGY AND AIR QUALITY	20
3.1	Meteorology Program	20
3.1.1	Equipment Specifications and Location	21
3.1.2	Seasonal Studies	22
3.2	Air-Quality Program	22

3.0 METEOROLOGY AND AIR QUALITY

The following section describes a comprehensive meteorological and air-quality program designed to provide the information necessary for assessing the impacts of oil shale development on Tract C-a. This program will identify natural air flows and emissions to provide baseline conditions necessary to measure the level of effluents from the oil shale development and to predict where the effluents will go and how they will disperse.

A 24-month data-acquisition period will provide baseline measurements. The exact influence of the plant upon the concentration of pollutants in the vicinity can be determined only after the plant becomes operational. However, a good background meteorological and air-quality history prior to the period of construction and operation will provide an inventory background of baseline conditions capable of analyzing trends in the measurements to be made.

3.1 METEOROLOGY PROGRAM

The meteorological program for assessing the air flows relating to Tract C-a will address two major objectives. The first will be the assessment of general circulation upper-level meteorological conditions that dominate the dilution and dispersion of stack effluents from the facility. The second major meteorological objective is the assessment of small scale or local wind flows that may exist in this region.

In addition to the local and synoptic-flow data-collection, the program will include a visibility study. Photographic techniques have been developed for determining climatologies of visibilities so that the distance

that one is able to see can be measured. Measurements of visibilities at regular intervals over two years will be directed expressly towards the long-range end of the spectrum. The theoretical limits for "seeing" distant objects through the atmosphere is about 150 miles and this study will be capable of estimating visibilities out to that distance.

Rainfall and snowfall measurements have been included to gather the necessary input for the hydrological studies.

Appendix B lists the specifics of these programs and of the instrumentation recommended for them.

3.1.1 EQUIPMENT SPECIFICATIONS AND LOCATION

The meteorological program as outlined herein is an expanded program over that recommended in the mineral lease stipulations and will provide a more complete assessment of the meteorological conditions at Tract C-a.

A more complete knowledge of the wind patterns, both synoptic and local, can be obtained through the use of two types of data-gathering equipment: one relating to permanent installations for long-term continuous data collection; the second directed toward more intensive, but short-term, data collection intervals. The long-term continuous program will utilize a tall tower located near the south edge of the tract on the ridge just to the south and east of Box Elder Gulch. This will provide for good exposure to upper-level atmospheric conditions. Its location is shown on Enclosure 4. The instrumentation for the tall tower will comprise wind speed, wind direction and temperature and humid-

ity measured at three levels. These levels will be at the 0-, 10- and 60-meter locations. The additional meteorological parameters of precipitation, snow depth, solar radiation, and humidity be recorded at ground level.

To complement this tall tower, three wind stations will be established at air quality stations on and about Tract C-a, for measurement of wind speed and wind direction. These sensors will be close to the ground (10 meters) and will collect data to assess the local wind flows within the region.

3.1.2 SEASONAL STUDIES

These studies are of an intermittent nature, intended for more intensive investigation in order to complement the long-term continuous programs. Until sufficient data is obtained from the permanent tower installations, exact specifications for these seasonal studies cannot be given. They are intended to supplement the basic tower data and fill in any "holes" in the program.

Seasonal studies may consist of pilot-balloon releases with theodolite, temperature, and humidity measurements as well as a tracer-diffusion study.

3.2 AIR-QUALITY PROGRAM

All the pollutants listed in Appendix C will be measured. Air-quality parameters will be measured at four locations for two years, one on the lease tract at the location of the meteorological tower, another to be at the location of expected maximum concentrations, the third and

fourth to be located in the surrounding area sufficiently spread apart to obtain a representative picture of the background air-quality parameters. It is anticipated, at this time, that the three air-quality stations not located at the meteorological tower on the leased tract will be mobile in nature so that they can be moved to different locations as the need for additional information becomes apparent. The locations of three of the four stations are specified on Enclosure 4.

The primary purpose of the four stations will be to monitor for sulfur dioxide, hydrogen sulfide and suspended particulates. Over and above these, the four stations will also monitor for hydrocarbons and the basic meteorological parameters: wind speed, wind direction and temperature. Oxides of nitrogen, carbon monoxide and ozone will be monitored at two locations, one at the main permanent station located on the lease site by the meteorological tower and the second located in a valley where there may be auto trafic in the future.

Section

Table of Contents

Section		Page
4.0	SPECIAL ENVIRONMENTAL STUDIES	24
4.1	Archaeology	24
4.2	Aesthetics - Scenic Values	24
4.3	Seismicity	25
4.4	Noise Measurements	26
4.5	Aerial Photography	26
4.6	Fish and Wildlife Management Plan	26
4.7	Protective Measures	27

4.0 SPECIAL ENVIRONMENTAL STUDIES

Certain environmental studies, investigations, and measurements do not lend themselves to neat classification, but are still important. This section contains environmental studies not included in the previous two chapters.

4.1 ARCHAEOLOGY

Anticipated development of oil shale lands in the Piceance Creek Basin will result in alteration of the physical nature of certain parts of the area. In accord with the Federal Antiquities Act of 1906, investigation of any sites of archaeological potential will be carried out under a permit issued to a recognized scientific institution and the necessary reports on analysis filed with the permit-granting agency. If archaeological sites are found which would be of sufficient importance to warrant excavation to recover additional information, this will be undertaken to comply with the Act.

Reviews will be conducted of existing archaeological investigations, including a study made in the summer of 1973 by Colorado State University and Thorne Ecological Institute. In addition, field studies will be conducted to survey and test the archaeological potential of Tract C-a and surrounding areas.

4.2 AESTHETICS - SCENIC VALUES

The subjective evaluations of aesthetic effects make the task of establishing standard qualitative values extremely difficult. Therefore, the parameters selected for assessing and evaluating any aesthetic

effect must be clearly defined so that a common reference framework can be provided for each observer.

For the purposes of this study, the parameters adopted as basic elements of the reference framework will include three of the five basic human senses expressed as visibility, noise and odor. Aesthetic effects also depend to a large extent on the time elapsing between occurrence and observation of the action, and to the relative distance between the action and the observer. These parameters will be used in subsequent analyses of short- and long-term effects, that is, effects of mining and related activities on Tract C-a.

Requirements for presentation of scenic values are covered by the parameters discussed above. Baseline information that can be applied to an assessment of effects on aesthetic or scenic values will be gathered in other study tasks including topographic mapping, biology, soils, meteorology and air quality. The topographic maps and aerial photomosaics will provide the necessary detail for visibility assessments. The biological and soils surveys will provide information regarding areas likely to be rated as sensitive. The baseline-visibility and ambient-noise data gathered in the air-quality task will provide the input for further assessing effects on scenic values on and near Tract C-a.

4.3 SEISMICITY

The purpose of performing a seismicity investigation for the site will be to determine the extent of seismic activity near the site due to earthquakes.

The results of this investigation will then be available for inclusion in the environmental baseline for Tract C-a.

To develop the information necessary for this study, a literature search will be made to establish both recorded and reported events in the area. Contact with existing observatories and recording stations will be established in an attempt to gather data on recorded events. Preliminary investigations indicate that events within about a 300-mile radius of Tract C-a should be included in the analysis.

Ground motion at the site as a result of seismic activity in the area will be established after analysis of all available data.

4.4 NOISE MEASUREMENTS

Noise will be monitored at least once per year at a minimum of six locations. The db-A weighted amplitudes will be measured in addition to both the broad-band and octave-band spectra.

4.5 AERIAL PHOTOGRAPHY

Color and color-infrared photography can be most helpful to many of the biological and soils studies for both mapping and interpretation purposes. Further, photographs will provide comparative records at known periods of time. A description of the size of the overflight area and approximate timing of overflights is contained in Section 5.3.1.

4.6 FISH AND WILDLIFE MANAGEMENT PLAN

Lease stipulations could be interpreted to mean that a fish and wildlife management plan should be formulated in the Exploration Plan. For lessees to conduct such a management plan would be to usurp govern-

mental authority. However, all cooperation will be extended to proper governmental agencies so that they can conduct fish and wildlife management plans best suited to the area. Much of the data gathered during the exploratory phase should be directly applicable to development of a fish and wildlife management proposal for inclusion in the Detailed Development Plan.

Need for special management plans during the development and operational phases of the prototype oil shale program on Tract C-a are obvious. Because of the seasonal nature and small scale effort during the exploratory phase, need for special game management plans does not appear necessary at this time.

The most likely disturbance during the exploratory phase may be some interference with big game hunting in the immediate area of the lease. Necessary measures will be taken, such as posting notices on and near the tract, to protect personnel from being exposed to stray bullets. Lessees will also post in reasonable and conspicuous places notices informing its employees, agents, contractors, subcontractors and their employees of all applicable laws and regulations governing hunting, fishing and trapping.

4.7 PROTECTIVE MEASURES

Protective measures for prevention of air pollution, fire, soil erosion, damage to fish and wildlife habitat, and prevention of public health and safety hazards are described in Sections 5.0 and 10.0 and Appendix D.

Section

Table of Contents

Section		Page
5.0	GEOLOGIC EXPLORATION PLAN	28
5.1	Introduction	28
5.2	Geologic Summary, Tract C-a	28
5.2.1	Structure	28
5.2.2	Stratigraphy	29
5.2.2.1	General	29
5.2.2.2	Oil Shale Section	30
5.2.2.3	Accessory Minerals	31
5.2.3	Conventional Oil and Gas Tests	33
5.3	Exploration Plan	33
5.3.1	Aerial Photography	33
5.3.2	Photogeologic Mapping	34
5.3.3	Surface Geologic Mapping	35
5.3.4	Topographic Mapping	35
5.3.5	Core Hole Program	36
5.3.6	Seismic Program	38
5.3.7	Summary, Geologic Evaluation	39

5.0 GEOLOGIC EXPLORATION PLAN

5.1 INTRODUCTION

The geologic exploration plan is designed to satisfy the needs of engineering, environmental and ground-surface water personnel to provide data necessary for the optimum development of Tract C-a's oil shale resources. For example, the proposed overflight area for new aerial photography far exceeds that considered essential for adequate geologic evaluation of the tract, its immediate vicinity, and two potential downstream reservoir dam sites. This relatively large overflight area will also provide new aerial photo coverage for additional investigations, other than geologic, presented in other portions of the overall Gulf-Standard Exploratory Plan.

In support of the proposed geologic exploration plan and to more fully explain its objectives, a summary is presented of the tract's geology as currently known or interpreted. Both this geologic summary and the geologic exploration plan are keyed to Enclosures 1, 2 and 3 of the overall Gulf-Standard Exploratory Plan.

5.2 GEOLOGIC SUMMARY, TRACT C-a

5.2.1 STRUCTURE

As shown on Enclosure 1, Tract C-a is regionally located on the west flank of the Piceance Creek Basin about five miles east of Cathedral Bluffs. Structure within the tract as interpreted from available surface, subsurface and photogeologic information is portrayed on Enclosure 2.

Beds within the tract generally strike to the north and dip basinward to the east at an average rate of about 200 to 300 feet per mile. A low relief anticlinal nose plunges southeast across the tract's southern portion. Three en echelon northwest-trending grabens parallel the axis of this structure, the most northerly of which essentially bisects the tract. A fault mapped by the USGS east of the tract may be a southeast extension of this graben. The central graben lies immediately north of the anticlinal axis. The southernmost graben appears to be in direct alignment with the USGS-defined Stake Springs Draw graben southeast of the tract and may be a northwest extension of that fault system. Within the boundaries of the tract, fault displacement ranges from a few feet to about 200 feet.

5.2.2 STRATIGRAPHY

5.2.2.1 GENERAL

The Green River Formation of Tertiary Eocene age comprises all surface rocks within Tract C-a. The uppermost Evacuation Creek Member, consisting mostly of interbedded sandstone, siltstone and barren marlstone, covers the vast majority of the tract's surface. In some of the major drainages, the uppermost beds of the underlying Parachute Creek Member are exposed in the valley walls. It is this member which contains the main oil shale interval discussed in detail below. The Garden Gulch and Douglas Creek Members underlie the Parachute Creek Member and are undifferentiated under Tract C-a. These members consist mainly of interbedded true shale and siltstone with some oil shale, limestone and sandstone.

5.2.2.2 OIL SHALE SECTION

Enclosure 3 shows a SW-NE cross section approximately normal to isopach (depositional) strike of the Parachute Creek Member's main oil shale interval and well portrays its stratigraphic characteristics throughout the entire tract. This interval is generally defined at its top by the top of the Mahogany zone or A-groove and at its base by the Blue marker or top Garden Gulch Member. This lower boundary coincides with the base of the Parachute Creek Member's high resistivity zone on electric logs. Although some rich oil shales occur immediately above and below the main oil shale interval, the thickest rich oil shales are within the stratigraphic section between the two markers described above. Both these electric log markers are regionally persistent throughout the Piceance Creek Basin and are extremely useful in defining the main oil shale interval's structure and thickness, both regionally and locally.

Two additional electric log markers shown on Enclosure 3 are also excellent correlative markers throughout the basin. The B-groove immediately underlies the Mahogany zone and the Orange marker defines the lower stratigraphic limit of rich oil shale in the uppermost Garden Gulch Member.

The Mahogany marker is an important lithologic marker throughout the Piceance Creek Basin. It is an analcimized tuff bed, generally 2 to 6 inches thick. Within Tract C-a, it lies about 25 to 30 feet below the middle of the A-groove in the uppermost part of the Mahogany zone.

The main oil shale interval is not uniform in oil content from top to bottom, but consists rather of alternating rich shale zones and relatively leaner oil shale zones. The areal persistence of these zones

has long been recognized in the literature. In 1972, Cashion and Donnell of the USGS (reference shown on Encl. 3) published a Utah-Colorado correlation chart which divides the main oil shale interval into several rich oil shale zones separated by leaner shale and designated Mahogany and R-6 through R-2 in descending order. As shown on Enclosure 3, all these rich zones are present within Tract C-a together with two additional deeper rich zones which are designated R-1 and R-0 (R-zero) using the Cashion-Donnell rich zonal nomenclature.

The upper and lower boundaries of the rich shale zones portrayed by Enclosure 3 are arbitrarily defined by individual shale beds assaying 25+ G/T oil. One could take the same three core holes' histograms and using a higher or lower yield for zonal boundaries, arrive at thinner or thicker rich shale zones, respectively. However, using 25+ G/T oil shale as the zonal boundaries conveniently separates rich zones from intervening lean zones throughout Tract C-a.

As shown by the inset map on Enclosure 3, the main oil shale interval regionally thickens basinward toward the northeast across the tract and averages about 900' within the tract. Its average G/T oil yield also increases in the same general direction as evidenced on the histogram cross section.

The main oil shale interval lies at a depth of about 100 to 850 feet under Tract C-a with an average overburden thickness of about 450 feet.

5.2.2.3 ACCESSORY MINERALS

(a) Dawsonite [$NaAl(OH)_2CO_3$], a potential ore of alumina, is present within the lower portion of the main oil shale

interval's R-5 through R-2 zones within Tract C-a. It occurs predominately as microscopic crystals finely disseminated throughout the oil shale. Regional information together with USBM X-ray diffraction mineral analyses of two Cameron core holes within the tract (CE 707 and CE 702, Encl. 2) indicate about 475 to 520 feet of dawsonite-bearing oil shale is present within Tract C-a with the thickness increasing basinward across the tract to the northeast. Its concentration is highly variable ranging from a few to as high as 15 weight percent in individual thin beds.

(b) Nahcolite ($NaHCO_3$), a potential ore of soda ash, is also present within Tract C-a, but apparently not in significant amounts. It probably was once widely distributed throughout the entire main oil shale interval occurring predominately as isolated nodules rather than beds. However, subsequent removal of this highly soluble mineral by ground water leaching has reduced its original concentrations considerably. In fact, this leaching is very likely continuing at the present time as evidenced by the highly saline ground water present in the tract's lower main oil shale interval. Core holes throughout the tract contain abundant solution cavities or vugs which were probably once filled with nahcolite. Only in the extreme northeast portion of the tract, the part farthest basinward, are a few thin beds of nahcolite present ranging in thickness from

a few inches to a maximum of two feet (CE 702, Encl. 3). Similar to dawsonite, its occurrence increases basinward to the northeast across the tract, but its present occurrence appears not only related to its primary mode of deposition but also to the degree it has been secondarily removed by ground water leaching.

5.2.3 CONVENTIONAL OIL AND GAS TESTS

No conventional oil or gas production has been found within Tract C-a. British American drilled a 5,526-foot Mesaverde dry hole (1958) in the tract's southwest corner and Occidental drilled a 6,429-foot Mesaverde dry hole (1969) in the tract's northeast corner. Minor shows of oil and gas were reported in the British American well in the Teritiary lower Green River and Wasatch Formations and the underlying Cretaceous Mesaverde group.

5.3 EXPLORATION PLAN

5.3.1 AERIAL PHOTOGRAPHY

Shown on Enclosure 1 is an area consisting of approximately 380 square miles to be overflown for new color and color-infrared aerial photography. As stated previously, this area far exceeds that required for adequate geologic evaluation of Tract C-a, its immediate vicinity and two potential downstream reservoir dam sites. The relatively large overflight area will provide new photo coverage as base control for detailed environmental, mining, surface drainage, access roads and facilities investigations.

The area outlined includes:

(a) All surface drainages upstream of Tract C-a to Cathedral Bluffs and downstream to the confluence of Yellow Creek with the White River.

(b) Access routes to the tract from Piceance Creek road to the east.

(c) Proposed federal withdrawn areas west of the tract immediately east of Douglas Creek road (Federal Register, January 3, 1974).

(d) The three areas for photogeologic, surface geologic and topographic mapping discussed below.

Prior to overflight, survey parties will establish necessary ground control including the location and appropriate marking of section corners within the three areas for topographic mapping shown on Enclosure 1. These corners will be readily identifiable on the new photos for construction of controlled mosaics and base maps.

Overflight is planned for 1974 after snowmelt and before extensive vegetation growth for both color and color-infrared photography. The area will be reflown for color-infrared in the summertime after vegetation growth is well established. Two reflys are planned for 1975.

5.3.2 PHOTOGEOLOGIC MAPPING

A detailed photogeologic interpretation, with particular emphasis on definition of fault and joint systems, will be made of the three areas designated on Enclosure 1 as Tract and Vicinity, Duck Creek Dam Site and Yellow Creek Dam Site. The total area to be critically examined is about 85 square miles.

The Tract and Vicinity area is also portrayed in more detail on Enclosure 2 and includes the areas shown on Figures 1 and 4 of the Gulf-Standard Preliminary Development Plan dated January, 1974. These figures show preliminary off-tract areas under consideration for plant sites, overburden-spent shale disposal areas and a near-tract reservoir site.

Photogeologic interpretation of the new color and color-infrared photos followed by field checking (see surface geologic mapping) will further refine the structural interpretation of Tract C-a as shown on Enclosure 2. Of particular importance is the further definition of the known fault systems within and in the vicinity of the tract and the possible location of others which are currently unknown. Preknowledge of the exact locations, trends and displacement of faults is essential to the proper selection of any plant or reservoir site and the planning of mining operations, particularly those underground.

5.3.3 SURFACE GEOLOGIC MAPPING

Surface geologic mapping will immediately follow photogeologic mapping of the same three areas outlined on Enclosure 1. Up to four crew-months of surface mapping is planned for the summer and fall of 1974. All photo-defined and suspected faults together with joint and fracture systems will be field checked. The importance of adequately mapping fault systems has already been stressed. Joint and fracture systems are also important in the planning of surface facilities as well as underground mining operations.

5.3.4 TOPOGRAPHIC MAPPING

Engineering personnel will require detailed topographic maps of the three areas outlined on Enclosure 1 for optimum planning and

implementation of those plans. The new aerial photography together with necessary additional ground surveying will be utilized to construct these maps. At the present time, topographic base maps at a scale of 1 inch = 200 feet and a contour interval of 5 feet are considered necessary.

5.3.5 CORE HOLE PROGRAM

Twelve core holes have been drilled on Tract C-a as shown on Enclosures 2 and 3. However, three TOSCO core holes duplicate three drilled by Cameron Engineers. This results in a net nine core holes currently available with which to plan the development of the tract's oil shale resources.

An "in-fill" program consisting of 15 new core holes, supplementing those already drilled, is planned to obtain sufficient shale resource, overburden and subsurface structural data necessary for detailed predevelopment planning. Locations of these 15 new core holes are shown on Enclosure 2. Several of the planned and existing core holes will also be used for further hydrologic testing. Two of the new core holes are located in grabens to determine:

(a) Accurate fault displacements.

(b) Fault zone hydrologic conditions.

(c) The presence or absence of highly fractured zones associated with the faults which may preclude underground mining in or near the grabens.

(d) The underground mineability of rich oil shale intervals offset by the faults.

The above 15-hole program will be drilled this summer and fall so that the information obtained can be evaluated during the winter months of 1974-75. This will require the concurrent use of three or more drilling rigs.

Continuous coring will begin in each hole as soon as competent bedrock is encountered and end at the Orange marker, total depth, to obtain core data on overburden characteristics as well as the entire oil shale sequence. Oil yield assays will be run at 2-foot increments starting 100 feet above the A-groove and ending at the Orange marker as portrayed on Enclosure 3, cross section.

In about eight selected core holes spaced across the tract, the following additional analyses will be run at two-foot increments from 100 feet above the Mahogany zone to total depth:

(a) Extractable alumina analysis in the spent shale from core assays to determine its concentrations for potential economic recovery.

(b) Trace element analysis on fresh and spent shale for boron, fluorine, mercury, arsenic, antimony and cadmium, all of which are important for environmental reasons in potential stock pile and spent shale disposal areas. Minerals in which these elements are contained will also be identified.

The United States Bureau of Mines, Laramie, is not available for the extensive project of assaying the planned 15 core holes because of their normal work load and other responsibilities. Therefore, the oil yield assays will be performed using techniques comparable to those of the USBM (Modified Fisher Assay).

The appended Drilling and Operating Plan is for the 15-hole program discussed above (Appendix D). It is patterned after the plans submitted to the Mining Supervisor, USGS, for Special Land Use Permits C-18269 and 18375 under which Amoco Production Company (a subsidiary of Standard of Indiana) drilled three core holes on Tract C-a in late 1973.

Consideration will be given to drilling additional core holes outside the tract as necessary to supplement the "in-tract" 15-core hole program discussed above.

5.3.6 SEISMIC PROGRAM

About 10 miles of shallow high resolution reflection seismic lines are planned on Tract C-a during the summer of 1974 as shown on Enclosure 2. The seismic lines are mainly oriented in a NE-SW direction perpendicular to the strike of the beds and are designed to make full use of the existing roads and trails. Two short profiles across the valleys near the western edge of the tract are being considered for valley-fill information.

The objectives of this seismic program are to further define the known surface faults and their characteristics at depth, perhaps locate others which are not exposed at the surface, check the continuity of the oil shale section and determine valley-fill depths. Experimental shooting during the first few miles will determine necessary equipment, shothole depths, charges, spreads, etc., to obtain best seismic record quality.

About one month will complete the proposed program. Off-road

vehicle use will be kept to a minimum and all shotholes plugged to the satisfaction of the Mining Supervisor upon completion of the program.

5.3.7 SUMMARY, GEOLOGIC EVALUATION

As new information is obtained from all phases of the proposed geologic exploration plan, it will be incorporated into existing geologic control to monitor the implementation of the entire plan from beginning to end.

Assaying will be done concurrently with the core hole program as core is obtained. Data will be input into the computer system for construction of G/T yield histograms and G/T yield calculations of selected zones. Structure, isopach, and G/T yield maps of these zones will be updated continuously on a "rough draft" progress basis.

After all programs are completed and all geologic information obtained, final cross sections, structure, isopach, G/T oil and extractable alumina yield maps will be prepared for specific zones and combinations of zones. The distribution of nahcolite within the tract will also be mapped, should significant concentrations be located with the planned core hole program.

Section

Table of Contents

Section		Page
6.0	HYDROLOGY	40
6.1	Surface Water Monitoring	40
6.1.1	Data Collection and Analysis	41
6.2	Subsurface Hydrology	42
6.2.1	Purpose	43
6.2.2	Data Collection	44
6.2.3	Data Interpretation and Analysis	47
6.2.4	Monitoring Program	48

6.0 HYDROLOGY

6.1 SURFACE WATER MONITORING

The oil shale lease environmental stipulations specify the following surface water baseline monitoring program:

(a) Gauging stations shall be constructed on the major drainages...and, as required by the Mining Supervisor, upstream and downstream from the lease lands.

(b) Data collected at the stations shall include continuous streamflow, precipitation, sediment and water temperature records.

(c) Periodic analyses for selected inorganic and organic chemical constituents.

The system of water-monitoring and gauging stations described below is designed to meet these minimum requirements and to afford additional capability to detect any adverse effects caused by the development at some distance from the tract.

The United States Geological Survey, under contract with the Colorado River Water Conservation District, arranged for and funded by the lessees, has installed and is operating five temporary gauging stations in the Yellow Creek drainage near Tract C-a. The location and design of the gauging stations to conform to the lease stipulations was established in consultation with the District Water Resources Division of the USGS and beginning of data collection accomplished through expeditious handling and cooperation by the USGS. These temporary stations were designed and installed in consultation with the USGS in order to capture baseline surface

water data for the beginning runoff of 1974.

All of these stations eventually will be equipped to automatically record water flow rate and to monitor sediment discharge, water temperature and specific conductance. In addition to the five stations cited above, an existing station on Yellow Creek near the White River will be rehabilitated and equipped to monitor the same parameters for the program. Two of the stations will include rainfall intensity monitoring equipment and an additional rainfall intensity gauge is planned to be located at the head of the drainage basin near Cathedral Bluffs. Locations of the stations are shown on Enclosures 2 and 4.

6.1.1 DATA COLLECTION AND ANALYSIS

The data-collection and analysis program also has been established through the cooperation and advice of the Water Resources Division, Colorado District, USGS. Until these stations are equipped to automatically collect samples, weekly sediment and water-quality samples will be taken. Quantity of flow records will be collected automatically and recorded in accordance with USGS standard procedure. The initial and final sampling and analysis programs, referred to by USGS as a Schedule I program, will include the following:

(a) An ETR sediment sample shall be collected at lease once each week and analyzed for concentration and particle size finer than 62 microns. Final sediment sampling will be automatic and sampling frequency will be automatically increased during runoff events.

(b) Specific conductance, water temperature, pH, and dissolved oxygen measurements shall be taken.

(c) Water quality samples shall be collected each week for four consecutive weeks. The samples will be analyzed for Schedule I constituents plus cadmium, arsenic, selenium, and mercury. A sampling procedure will be developed based on specific conductance following the initial four-week sampling period.

(d) Two samples for spectrographic analysis will be collected at each station. The samples will be collected during high-flow and low-flow periods. The collecting and sampling program may be expanded should the spectrographic analysis reveal such a need.

Chemical analysis and data interpretation will be performed by the USGS laboratory center in Salt Lake City, Utah. All flow records and other data and sampling analysis will ultimately be published as open-file records in accordance with standard USGS procedures.

6.2 SUBSURFACE HYDROLOGY

At least three distinct aquifer systems can be identified beneath Tract C-a. Surficial alluvial material in the stream channels form the uppermost aquifer system. These unconfined aquifers contain water in varying amounts and probably respond directly to infiltration of precipitation and surface water runoff. An "upper" artesian aquifer zone exists within the upper part of the Parachute Creek member of the Green River formation. The exact thickness, lithologic characteristics, and hydrologic

properties of this aquifer zone are ill-defined, although the zone appears to have relatively wide aerial extent. A second "lower" artesian aquifer zone exists near the base of the Parachute Creek member. This lower aquifer zone is likewise ill-defined, although it appears to have wide aerial extent.

Movement of water within the alluvial-stream channel deposits appears to be relatively uncomplicated. Ground water movement within the two artesian-aquifer systems is complicated by a general lack of primary hydraulic conductivity (permeability). Apparently all significant ground water flow within the artesian aquifers is by way of either interconnected vugs formed from leaching of soluble minerals, or through fractures and/or joints within the rock mass. In either case, the baseline conditions of the artesian ground water regime are not well known.

6.2.1 PURPOSE

The following paragraphs describe the proposed investigation to obtain hydrologic data of sufficient quality to allow a reliable interpretation of the existing ground water regime beneath the project area. Some changes likely to occur as a result of the proposed mining development might be predicted by the use of a flow model and a compositional model. Such models would be quite helpful in the design of mine dewatering facilities and might also indicate what effects may be expected off the tract. It is anticipated that data obtained during this program could be used in the USGS Water Resources models to provide an analysis of the effects of various dewatering methods. The actual changes as detected by the monitoring program could be compared to predicted changes.

The investigation will include gathering basic data, analysis and interpretation of these data in relation to the proposed shale oil recovery operation on the lease, and a continuing program for monitoring both the ground water regime and ground water quality as the project is developed.

The available published and unpublished data have been reviewed. Based upon this review, a program to collect baseline hydrologic data has been formulated. The program is tentative because the current ground water flow conditions appear to be relatively complex. It may be subject to revision during implementation as data become available during the course of geological exploration of conditions beneath the site and as the subsurface ground water regime is defined by pump tests and the information itemized below. The program is designed to provide information on existing ground water conditions including:

(a) Water-table elevations.

(b) Piezometric surface elevations.

(c) Radius of influence of pumping holes with time.

(d) Water quality.

(e) Physical characteristics of aquifers.

6.2.2 DATA COLLECTION

Twelve shallow hydrology observation holes will be completed in the alluvial aquifers most likely to be affected by the development of the site. All but one of the alluvial observation holes will be completed off the tract around its perimeter.

In addition to the shallow alluvial holes, 26 observation holes

will be used in the data-collection program for the deeper artesian aquifers. The holes which are necessary for this program will include 10 of the existing holes on the tract, 12 of the 15 new core holes which will be cored on the tract for resource and geological information (see Section 5.0), plus four holes drilled specifically for hydrologic data, one on the tract and three off the tract. The tentative locations of all the observation holes are shown on Enclosure 2.

The 26 deeper observation holes will penetrate both the upper and lower aquifers. However, the upper and lower artesian-aquifer zones will be hydraulically isolated within each observation hole. To accomplish this, it is planned that the aquifers will be isolated by setting casing in each of the test holes about 100 feet below the bottom of the Mahogany zone. The actual casing point would be based on data obtained during the drilling of the hole and from logs. The hole below the casing would be left open.

A minimum casing size of 5-1/2" O.D. would be used in the newly drilled observation holes. It will be necessary to use 4" O.D. casing at six of the old core holes because of the size of the surface pipe already set. A packer would be set near the bottom of the casing and 2-3/8" tubing will be run through the packer to obtain samples and fluid levels from the lower aquifer. The casing will be perforated or set in such a manner that the upper aquifer can be sampled and pressure or fluid level determined. The observation holes will remain in use indefinitely.

Four of the observation holes will be used for pump tests in the deeper aquifer zones so that the aquifer water-yielding characteristics can be measured. The pump tests will be started after the drill-

ing program is completed and after water levels stabilize within the observation holes. Both aquifer zones will be tested separately by pumping the four holes in sequence while hydraulically isolating the aquifer zones within the pump-test holes.

The pump-test holes will be completed as described previously. Larger casing (7" O.D.) will be used in two of the pump-test holes, and the other two pump-test holes will be equipped with 5-1/2" O.D. casing because of the surface casing already set. These pump-test holes are all located on the lease tract. Each aquifer zone may be pumped for several days, the length of time to be established as drawdown data are obtained.

Pressures or fluid levels will be monitored above and below the packer during the pump tests to determine if there is leakage around the packer or behind the pipe.

Fluid level or pressure at all 26 observation holes will be monitored prior to, during the pumping test program, and for an extended period thereafter.

A water sample will be collected at each pump-test hole when the pump test starts, every third day during the pump test and when the pumping test is finished. This will be done for both the upper and lower aquifers. The type of analysis to be done will be similar to that outlined in Section 6.2.3.

At least one of the test holes (Number 16) will be completed in the underlying Douglas Creek member of the Green River formation to identify possible deeper aquifer zones. It is not anticipated that aquifers underlying the Parachute Creek member will be pump tested.

It is planned that temperature and spinner logs, plus possibly other logs, will be run in 10 of the core holes which are now on the tract. This will be done to determine if ground water conditions have changed since the previous logs were obtained.

Additional basic information will be obtained from geophysical logs, such as resistivity, spontaneous potential, caliper, temperature, neutron and spinner, which may be run in the observation test holes.

Water samples will be collected every 200 feet during the drilling of the new holes. Three samples, one representing the section above the Mahogany, and two from below the Mahogany, will be analyzed to determine the variation of water quality with depth.

All field work and data collection will be done under the direct supervision of a hydrologist who will be assigned to the project and will work on the site.

6.2.3 DATA INTERPRETATION AND ANALYSIS

Water-level, water-quality, geophysical, and test-pumping data obtained during the course of the investigation will be analyzed and interpreted. The analysis will include calculations of the artesian aquifer transmissivities, hydraulic conductivities, and coefficients of storage. The hydraulic gradient and variations in existing water quality will be calculated for the alluvial aquifers as well as the two artesian-aquifer zones.

Water quality will be determined from analysis of samples from the observation and test holes. In the initial water analysis, about 50 elements, ions and compounds will be monitored using emission spectrography

or other suitable chemical analysis. Those trace elements such as mercury, boron, fluorine, arsenic, antimony and cadmium which are of environmental concern will be determined and monitored unless it can be established, after suitable time, that the concentrations of these trace elements are so low as to be of no importance.

After the initial samples are analyzed, consultation liaison will be maintained with appropriate federal, state and local authorities and a quality-element list prepared to assure that all constituents of interest are included in the analysis. All of these parameters will provide information useful in the prediction of possible hydrologic changes which may result from development of Tract C-a.

Ground water movement, quality and volume will be evaluated in relation to geologic criteria such as faulting, fracturing, jointing, lithology, and general structure. Areas of ground water recharge and natural discharge will be identified on the basis of hydrogeologic principles as well as existing data.

6.2.4 MONITORING PROGRAM

A systematic water-level and water-quality monitoring program will be continued during development of the lease so that significant changes in baseline conditions can be measured and analyzed. From this information it may be possible to anticipate or detect undesirable changes as they first occur.

After the initial water samples are obtained and analyzed, water samples would be collected monthly from all of the test holes. After a trend has been established, perhaps in six months, the sampling frequency

would be reduced to once each six months. Water levels or pressures in the deep test holes would be measured by means of permanent installations which would record pressure or water level continuously. Water levels in the alluvial holes would be measured monthly with a tape and after sufficient history was accumulated, perhaps a year, the frequency would be reduced to once every six months.

Section

Table of Contents

Section		Page
7.0	MINING	50
7.1	Mining Studies	51
7.1.1	Conventional Mining	51
7.1.1.1	Reserves	51
7.1.1.2	Mine Design	52
7.1.1.3	Equipment Selection	53
7.1.1.4	Overburden, Waste and Spent Shale Disposal	53
7.1.1.5	Development Plan	54
7.1.2	Potential Future Mining Methods and Equipment	54
7.2	Geotechnical Testwork	55

7.0 MINING

The primary objective of the mining portion of the Exploratory Plan is to determine the most suitable conventional mining method for Tract C-a. This emphasis on conventional mining methods is based on the lessees' belief that the use of proven mining technology, techniques, and equipment, in particular those pertaining to open-pit mining, will provide the most suitable means for early start-up and development of commercial operations on Tract C-a, commensurate with sound engineering, environmental and operating considerations.

In addition, the mining portion of the Exploratory Plan also includes studies of new or conceptual mining methods that have potential as superior means of extraction--as compared to conventional mining--in terms of resource recovery, environmental aspects and economics.

Following the initial office studies, further research of selected methods will be actively pursued. The ultimate objective is to develop new mining methods, techniques and equipment which will replace conventional approaches and optimize shale extraction operations. It is likely that development of these new techniques will require field testing, most of which probably will be done after start-up of commercial operations.

In order to achieve the objectives outlined above, the mining portion of the Exploratory Plan consists of: (1) studies of mining methods, and (2) laboratory geotechnical tests.

The major part of the mining studies will be an in-depth study of two conventional methods; i.e., (1) open-pit mining, and (2) under-

ground room-and-pillar mining in selected intervals, both using only proven or semi-proven techniques and equipment. The relative merits of each--taking into account technical, environmental and economic aspects--will determine the mining method that will be included in the Detailed Development Plan. The studies will make extensive use of data developed by the other portions of the Exploratory Plan; i.e., the environmental baseline studies, geotechnical drilling and analyses, and hydrogeological research.

Studies and analyses conducted in the mining portion of the Exploratory Plan will be performed by the lessees' staff and by contractors and engineering consultants under the lessees' guidance. No underground pilot mines or test pits are presently planned for this stage of the project.

7.1 MINING STUDIES

A more detailed description of various aspects to be covered by mining studies is as follows:

7.1.1 CONVENTIONAL MINING

7.1.1.1 RESERVES

"Economic reserves" available for open-pit and room-and-pillar mining will be estimated using cutoff grades based on the best available cost and economic data. These estimates will be combined with the results of mine design and planning work to arrive at economically recoverable reserves for open-pit and room-and-pillar mining.

Included in reserve considerations will be an in-depth study of methods and economics of extracting dawsonite and nahcolite from the oil shale. To the extent that the commercial potential of these minerals can be developed, allowance will be made in extraction studies and plans for their recovery.

7.1.1.2 MINE DESIGN

General parameters will be studied and selected for design and engineering of both open-pit and underground room-and-pillar mining. For open-pit mining, these parameters will include such items as pit slope and economic and operational pit limits. Parameters for underground mine design will include the selection of intervals suitable for room-and-pillar mining, based on economic and operational criteria. Determination and use of parameters for general mine design will be followed by extensive studies concerned with specifics of mine design and equipment selection. It is expected that particular attention will be required in the areas of rock mechanics; pillar dimensions and spacing; maximum allowable mining heights; the determination of safe intervals between mining levels; and ventilation systems and procedures required for the relatively large room openings, as well as the possibility of gas occurrences.

Mine design criteria common to both open-pit and underground studies will include: rock-breaking techniques; shale and waste transportation; mine dewatering; high-production mine layouts; and federal and state health and safety regulations.

Design of the mine dewatering system will include facilities for disposal and/or treatment required for brackish or otherwise unde-

sirable water.

Data obtained from geotechnical analyses, drilling and laboratory tests will be used throughout the studies, particularly in the determination of safe open-pit and room-and-pillar design.

7.1.1.3 EQUIPMENT SELECTION

Equipment selection studies will be carried out concurrently with detailed mine design. Particular attention will be given to the use of data developed in previous oil shale mining operations pertinent to equipment selection. However, an attempt will be made to optimize wherever possible both specific mine design and equipment selection. Most of the the studies will be devoted to equipment selection for the basic mining operations: rock breakage, loading, crushing, hauling, roof support, dewatering and ventilation.

7.1.1.4 OVERBURDEN, WASTE AND SPENT SHALE DISPOSAL

The disposal of overburden, spent shale and other waste materials will be studied extensively, with particular emphasis on the selection of methods, techniques and disposal areas which will minimize environmental impacts. This will include: a complete analysis of chemical and physical properties of spent shale from various retorting processes; studies of the potential for disposal of waste materials in surface sites or in mined-out areas of open-pit or underground mine workings; selection of disposal locations; and evaluation and selection of various systems and procedures for transporting, placing, and compacting materials.

7.1.1.5 DEVELOPMENT PLAN

Comprehensive development plans for open-pit and/or room-and-pillar mining will be established using the selected mine designs and equipment. Maximum feasible rates of buildup to full production will be established. The location of initial mine openings and logical patterns of expansion will receive special attention, along with both the initial and ultimate locations of facilities such as processing plants, haul roads, conveyors, and ore stockpiles. Utility and manpower requirements for mine development will also be determined.

7.1.2 POTENTIAL FUTURE MINING METHODS AND EQUIPMENT

The objective of this part of the mining studies is to lay the groundwork for research and development of new mining methods, concepts and equipment. It is envisioned that this program, although initiated during the exploration period, will continue for many years beyond start-up of commercial operations.

As part of the Exploratory Plan, study of potential future mining methods will consist of the following:

(a) A survey and evaluation of new methods and concepts such as:

(1) Underground mining of the entire shale column by bulk mining techniques.

(2) In situ methods.

(3) Continuous Miners.

(4) Materials Handling "Innovations"

(b) Establishment of criteria, estimates of recoverable reserves, studies of techniques and equipment, and cost estimates and analysis.

(c) Evaluation and selection from the activities described in (b) above. A limited number of these methods will be selected for inclusion in the Detailed Development Plan for further research.

7.2 GEOTECHNICAL TESTWORK

The geotechnical analyses will consist of laboratory tests on cores obtained from the core drilling program described in the geologic portion of the Exploratory Plan. The test results, together with structural design theory and experience from work in similar formation, will serve as a first approximation of the structural behavior of the rock and so assist in the determination of preliminary design parameters for open-pit and underground mining plans. The laboratory tests will include determination of: bulk density, permeability, compressive strength, modulus of elasticity, Poisson's ratio, shearing strength, modulus of rupture, and behavior under point loading. Joint systems, their extent and orientation, also will be studied, as will bedding parting characteristics.

8.0 PROCESSING

Selection of the initial processing sequence for Tract C-a will involve comprehensive economic and environmental evaluations of the interrelated steps of mining, feed preparation, retorting, upgrading to desired product quality, and transportation and utility supply. Consideration must be given not only to the Detailed Development Plan, but also to potential future expansion.

Processes and equipment for the Detailed Development Plan will be chosen from first-generation technology available at the time. If such equipment is not available or if Tract C-a is judged to have unique processing problems, the first step of the Detailed Development Plan will, of necessity, include design, construction and operation of large-scale demonstration or prototype units to be followed later by the commercial-scale facilities which will comprise the first plant.

Gulf and Standard presently believe that the initial plant should have a minimum capacity of 50,000 to 100,000 BPCD. Determination of initial plant capacity and product quality will be one of the first major decisions in designing the first plant.

Planning of the processing facilities will take place concurrently with the mining studies outlined in Section 7.0. Like the mining studies, the work will probably consist of office studies conducted away from the tract. At present, it is not planned to make any field tests or installations prior to approval of the Detailed Development Plan.

Section

Table of Contents

Section		Page
9.0	WATER CONTROL AND CORRIDOR PLANNING	57
9.1	Reservoir	57
9.2	Corridor Planning	59

9.0 WATER CONTROL AND CORRIDOR PLANNING

The lease stipulations include the statement: "The lessee shall avoid, or, where avoidance is impracticable, minimize and, where practicable, repair damage to the environment." The water-control facilities necessary in connection with the development will be provided and designed accordingly. These facilities must include surface works to preclude damage from flash floods typical of the area, particularly in connection with spent-shale disposal. Works must be provided to ensure an adequate supply of water to permit optimum compaction and revegetation of spent shale for certain mining, upgrading and processing needs, and for associated urban uses. Water-control works may also be necessary to divert or dispose of excess saline waters, if encountered, in mine-dewatering operations. The location, design and extent of such works cannot be determined until after a number of engineering studies have been completed, each predicated upon the findings and conclusions reached in the prior study. Following completion of such studies and the initial design of works derived therefrom, exploratory field work will be undertaken to determine site conditions relevant to final design.

9.1 RESERVOIR

Fundamental to the water-control facilities is adequate storage capability to accommodate seasonal fluctuations of water supply, as well as unforeseen water shortages. The total facility must be capable of sustaining production through a period of interrupted water supply and be sufficient for provision of alternative supplies. Provisions for flood storage reserves should be incorporated into the reservoir opera-

tion plan. Other reservoir uses include flexibility of control and storage which may be utilized in connection with a water-treatment plant contemplated as an alternative means of poor-quality water control.

Two reservoir sites have been selected for further design and study as indicated on Enclosure 1. The northern or Yellow Creek Dam site offers an extremely promising site and preliminary studies indicate its selection. Nevertheless, the alternative site has been selected in the event field exploration or later studies reveal unforeseen detrimental conditions.

Prior to final site selection, the following studies in relation to alternative reservoir uses and related water-control problems must be made in the order indicated:

(a) A comprehensive water-quality, water-disposal study will be made. The ground water hydrology studies described elsewhere herein are partially aimed at determining the parameters necessary to predict ground water inflow to the mine, including quantity and quality assessment. If these studies indicate a high range of poor-quality water inflow is possible, plans must be formulated for water disposal. The most economical method of disposal of poor-quality water, and perhaps the most environmentally desirable, is through evaporation. Other methods of disposal or handling include injecting the water into deeper formations and water treatment.

(b) Surface runoff protection works will be required to minimize environmental damage in connection with spent-shale

disposal, to protect the mine facilities, and to control erosion damage. These works may include diversion dams, ponds, catchment ditches and canals, pipe conduits and other works. Each feature must be designed and integrated with the overall water-control plan for optimizing environmental protection.

(c) The desisions reached through the foregoing studies would form the basis for final selection, through detailed cost comparison and environmental assessment studies, of water supply, storage and protection works to be embodied in the Detailed Development Plan. These studies would include and integrate all features of the water-control plan in the Detailed Development Plan, including such features as diversion works, pumping plants, and pipelines to divert water from the White River, the Colorado River or the Yampa River, should importation of water prove necessary.

Following the above studies, anticipated to be completed by the summer of 1975, field investigations would be undertaken for site exploration. These investigations would include relatively shallow drilling for foundation investigations, soils and other materials investigations, and expanded contour mapping to include the sites of all finally selected water-control works sites.

9.2 CORRIDOR PLANNING

The lease stipulations require the lessee to provide corridor plans for roads, pipelines and utilities on the leased lands for approv-

al by the Mining Supervisor. It is planned, as described hereafter, that existing roads and facilities will be utilized during the exploration period in order to defer construction of substance, until after comprehensive planning studies have been made. The advantage of multiple land use through corridor planning vis-a-vis individual route selection for each facility is noted in the lease and has been stressed by the Bureau of Land Management. Planning efforts will be geared to this concept.

Prerequisite to establishment of multiple-use corridors is solution of several major questions facing the development, viz, the source and location of substantial quantities of power, the major markets for the product(s), and the areas selected by the personnel directly involved in the development for settlement. Following study and determination of these questions, final corridor planning will be undertaken.

It is planned that initial corridor studies will be fully comprehensive; all feasible alternatives and routes will be reviewed. For example, it may prove environmentally sound as well as economically desirable, to provide loop transportation routes to the site to encompass all areas of likely settlement; and the feasibility of mass transit systems will be studied. Cooperation among various developers in the basin would be paramount to this type of endeavor.

It is generally accepted that power requirements will need to be provided through power developments not now existing or planned. Sit-

ing plans for any new power development thus can integrate transmission-line requirements toward optimizing the total development. It is not anticipated that integration of pipelines in common corridors will pose any design problems.

Site exploration, including foundation and materials drilling and investigation and topographic mapping, will be undertaken following selection of the final plans and routes.

Section

Table of Contents

Section		Page
10.0	SUPPORT ROADS AND FACILITIES	62
10.1	General	62
10.2	Primary Roads	63
10.3	Facilities	64

10.0 SUPPORT ROADS AND FACILITIES

Exploration work as defined in the lease includes the construction of roads and trails and other necessary facilities. The requirements of 43 CFR 23 referenced in the lease include a "...statement of support roads and facilities." Enclosure 4 shows the support roads and facilities planned to be constructed and utilized during the exploration period.

10.1 GENERAL

The Piceance Creek Basin, as will be noted from Enclosure 4, is traversed by numerous roads and trails constructed or naturally made by hunters, ranchers and more recently by oil shale and other industrial interests. It is planned that existing roads will be utilized to the greatest practicable extent to minimize construction of new roads and the concomitant land use.

Needs for access roads during the exploration period are manifold; including access to drill sites for equipment, materials and operating crews, access for servicing and sampling the various baseline-data-monitoring stations, and access for personnel and equipment necessary to the comprehensive environmental assessment to be undertaken. Nevertheless, site inspection has indicated that, with few exceptions, the existing roads will fulfill exploration period needs with only minor upgrading and maintenance necessary.

The state and county maintain certain of the road facilities planned to be used, including snow-clearing during the winter period. It is anticipated that county jurisdiction and funding will be extended to service oil shale-industry needs as soon as administratively possible.

During the interim period, it is planned that the lessees will extend and augment the state and county maintenance efforts as indicated on Enclosure 4.

Final design of roads, incorporating the use of existing roads and integrating multiple-use corridors to the greatest practicable extent, will be undertaken during the exploration period for submittal with the Detailed Development Plan.

10.2 PRIMARY ROADS

It is anticipated that the main-use roads will be from Rangely, Meeker and Rifle, via State Highway, thence via the Piceance Creek Road and thence via the Ryan Gulch Road, as shown on Enclosure 4. These routes are maintained and snow-cleared by the state and county. An existing nonsurfaced road from the terminus of the Ryan Gulch cleared section to the southern midsection of Tract C-a will be upgraded, intermittently surfaced, and maintained open throughout the year by the lessees.

Access from the west to the northwestern corner of the tract will be provided, during the construction season only, by utilization of the BLM-constructed Calamity Ridge Road, which branches from State Highway 64 some 11 miles northeast of Rangely. This road will be extended by the lessees from near its present terminus some 11 miles to the tract. This road is not presently snow-cleared during the winter season and it is anticipated that it will continue to provide construction-season access only.

It should be noted that most of the drill sites are planned to be reached along existing trails or roads. There will, however, need to

be limited clearing work undertaken to provide access to certain holes, as well as clearing and leveling work for siting drill rigs over the proposed holes.

Adequate drainage culverts and other control works will be incorporated for all new and upgraded roads to minimize and control erosion damage.

10.3 FACILITIES

Provision of permanent housing and related facilities at the site have been held to a minimum to ensure that baseline environmental data will truly reflect, undisturbed, existing conditions at the site. A single trailer, equipped as a first-aid station, together with minimal field office furnishings, will be provided in conformity with the requirements of Occupational Safety and Health Administration. The trailer will be equipped for use as an emergency shelter in case personnel are accidentally isolated at the tract.

The trailer will be serviced by electric heating and power. Water supply and sanitation needs will be provided by delivery service trucks to ensure no contamination at the site.

Present telephone service lines into the area of Tract C-a are fully loaded. The Bell Telephone Company has determined that the nearest available telephone line extension required would be some 11 miles. Accordingly, it has been tentatively decided that mobile radio-telephone equipment capable of communications with a Bell Telephone radio-telephone network will be provided at the trailer field office. Remote-sensing capability may be integrated with this system.

It should be noted that nominal amounts of electric power are available near the tract. Arrangements have been made to extend existing power lines located less than one mile from the southeastern corner of the tract to service surface water-, air- and weather-monitoring stations.

APPENDIX A

PROJECT SCHEDULE AND MANPOWER

Year	1974				1975				1976			
Quarter	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
BIOLOGY, SOILS, REVEGETATION, RECLAMATION			7/1→	→	→	→	→	→	→	→	→	→
Avg. on-tract employees			5	5	4	4	4	4	4	4	4	4
METEOROLOGY AND AIR QUALITY		6/1→	→	→	→	→	→	→	→	→	→	→
Avg. on-tract employees	1	3	2		2	11	2	2	1	1	1	1
SPECIAL ENVIRONMENTAL STUDIES			7/1→	→	→	→	→	→	→	→	→	→
Avg. on-tract employees			10	5								
GEOLOGY AND HYDROLOGY		6/1→	→	→	→	→	→	→	→	→	→	→
Avg. on-tract employees	61	71	77		17	4	2	2	2	2	1	1
SUPPORT ROADS AND FACILITIES		5/1→	→	→	→	→	→	→	→	→	→	→
Avg. on-tract employees	12	12	10		7	5	3	3	3	3	3	3
TOTAL ON-TRACT EMPLOYEES	74	101	99		30	24	11	11	10	10	9	9
MINING AND PROCESSING STUDIES			→	→	→	→	→	→				
WATER CONTROL AND CORRIDOR STUDIES			→	→	→	→	→	→				
DETAILED DEVELOPMENT PLAN						→	→	→	→			

APPENDIX B - METEOROLOGICAL EQUIPMENT AND DATA ANALYSIS

B.1 TOWER

(a) The principal tower will be 60 meters tall.

(b) The wind instruments will be on a boom at least 3 meters from the nearest vertical tower component.

(c) The tower will be grounded properly to protect the instruments and maintenance personnel.

B.2 INSTRUMENT SHELTER

(a) The power source (excluding emergency power) must produce no exhaust gases that will contaminate the background air quality. Commercial power is suggested.

(b) The shelter must be sturdy and durable to the degree that it will withstand heavy snow and high winds.

(c) The shelter must be weathertight, heated and air-conditioned to control the environment of the signal conditioners, recorders and other sensitive equipment.

(d) The shelter will be at least 30 meters from the tower base.

(e) There will be a fence around the shelter and tower of sufficient size to reduce possible vandalism.

B.3 SIGNAL RECORDERS

(a) The wind recorders will continuously record the signals.

(b) All recorders will have an accuracy and readability of 0.5%.

B.4 MEASURING INSTRUMENTS

(a) The remote wind instruments on the three small towers will be 10 meters above the ground and measure wind speed and direction.

(b) The remote rain gauges will record continuously.

(c) Snow depth will be measured at three locations using a number of ruled stakes at each location. The stakes will be read at least twice per month and the average value assumed to be the snow depth.

(d) The tower instrumentation will be as follows:

60 Meters: Wind speed, direction, humidity and temperature difference from 10 meters.

10 Meters: Wind speed, direction, humidity, and absolute temperature.

Ground Level: Wind speed, direction, temperature, solar radiation, precipitation, and snow depth.

(e) The suggested instrument specifications are as follows:

Parameter	Accuracy
Wind Speed	±1% of reading or 0.2 mph, 0.6 mph threshold
Wind Direction	±3%, 0.6 mph threshold
Temperature Difference	$\pm 0.1^{o}F$
Absolute Temperature	$\pm 0.5^{o}F$
Precipitation	±0.01" Rain
Solar Radiation	No suggestion
Humidity	No suggestion
Snow Level	±1"

B.5 VISIBILITY MEASUREMENTS

The visibility will be measured at least every fourth day in coordination with the particulate sampling program. The visibility will be measured at least four times per day, nearly equally spaced throughout the daylight hours on that day. The technique used should measure in the 10 to 100 mile range with an accuracy better than ±15%.

APPENDIX C - AIR-QUALITY EQUIPMENT AND DATA ANALYSIS

C.1 INSTRUMENT SHELTERS (four)

(a) Shelters will be made of materials that are completely non-volatile so that there will be no contamination of background levels.

(b) If commercial power is not used, any power generation on site will not produce contaminants that may affect background air-quality levels.

(c) The instrument environment within the shelter will be closely regulated. The shelter will be weathertight and the temperature will be maintained to within 10^{o} F.

(d) The shelters will be capable of withstanding heavy snow and strong winds.

(e) The shelter will be surrounded by a fence of sufficient size to reduce possible vandalism.

(f) There will be provisions within a shelter for preparing, weighing and storing the High Volume samplers.

C.2 SIGNAL RECORDERS

(a) All recorders will have an accuracy and readability of $\pm$ percent.

C.3 MEASURING INSTRUMENTS

(a) Gas monitor and particulate sampler intakes will be at least ten feet above the ground.

(b) The wind instruments will be located in a clearing at 10 meters above ground and over 75 feet from the instrument shelter.

(c) The tower instrument shelter will monitor the following parameters:

(1) Nitrogen Oxides, Nitrogen Monoxide

(2) Hydrocarbons, Methane

(3) Sulfur Dioxide, Hydrogen Sulfide

(4) Carbon Monoxide

(5) Ozone

(6) Particulates, Particle Sizing

(d) A valley instrument shelter will monitor the following parameters:

(1) Nitrogen Oxides, Nitrogen Monoxide

(2) Hydrocarbons, Methane

(3) Sulfur Dioxide, Hydrogen Sulfide

(4) Carbon Monoxide

(5) Ozone

(6) Particulates

(7) Wind Speed and Direction

(8) Temperature

(e) The remaining two instrument shelters will monitor the following parameters:

(1) Hydrocarbons, Methane

(2) Sulfur Dioxide, Hydrogen Sulfide

(3) Particulates

(4) Wind Speed and Direction

(5) Temperature

(f) The instrument specifications will be as follows:

Parameter	Accuracy	Threshold
NO, NO_2	2% of Full Scale	5 ppb
SO_2, H_2S	2% of Full Scale	5 ppb
THC, CH_4	2% of Full Scale	5 ppb
CO	2% of Full Scale	500 ppb
O_3	2% of Full Scale	1 ppb
Particulates	±3% of Flow Rate, High Efficiency Collection In the 0.1 to 10 Micron Range	
Wind Speed	±1% of Reading or 0.2 mph	0.6 mph
Wind Direction	$\pm 3.5^{o}$	0.6 mph
Temperature	$\pm 0.5^{o}$	

C.4 DATA ANALYSIS

Correlations of the air-quality parameters will be made with wind speed, direction, month of the year and season. An attempt will be made to correlate the data with synoptic flow conditions and any other parameter that may have an effect on the background data.

Background air quality averages will be performed consistent with the averages covered by the federal and state air-quality standards.

APPENDIX D - CORE HOLE PROGRAM: DRILLING AND OPERATING PLAN

D.1 INTRODUCTION

As co-owners of Federal Tract C-a oil shale lease, Gulf-Standard propose a drilling program consisting of 15 core holes on the tract. The purpose of this program is to secure "in-fill" core hole control, supplementing the core holes now on the tract, and obtain sufficient data necessary for detailed predevelopment planning.

Before any on-the-ground activities can commence, a drilling and operating plan must be filed and approved which sets forth the plans to implement the 15-core hole program. This document is submitted to fulfill that requirement.

D.2 CORE HOLE INFORMATION

The core hole locations are shown on Enclosure 2 and numbered 1 through 15. The order in which they are numbered does not imply any priority or order in which they will be drilled. The numbering is used only as a convenience to relate map core hole locations to the text.

The locations have been selected on topographic maps and have yet to be ground-checked and surveyed. They are listed below using the "quarter-quarter" system. Preliminary access routes (Enclosure 4) to each location have also been selected on topographic maps considering minimum disturbance of the terrain and maximum use of existing roads (see Access for additional information regarding federal approval of core hole sites and access routes).

CORE HOLE NUMBER	LOCATION
1	NE SW 32-1S-99W
2	NW SW 33-1S-99W
3	NE NW 33-1S-99W
4	NW NW 34-1S-99W
5	NE SW 34-1S-99W
6	SE SE 34-1S-99W
7	SE NW 5-2S-99W
8	NE SE 5-2S-99W
9	SE NW 4-2S-99W
10	NW SE 3-2S-99W
11	SW SW 9-2S-99W
12	NE SW 9-2S-99W
13	NW NE 9-2S-99W
14	SW NW 10-2S-99W
15	SE SE 10-2S-99W

The geologic prognosis for each core hole is summarized below and is based on:

(a) Surface elevations estimated from topographic maps.

(b) The middle A-groove structure map or top main oil shale interval as shown on Enclosure 2.

(c) The main oil shale interval isopach shown on Enclosure 3 as A-groove to Blue marker interval.

(d) An average additional interval of 250 feet throughout

the tract from the Blue marker to reach the Orange marker as shown on Enclosure 3.

Each core hole prognosis may be modified slightly when ground locations and their surface elevations are surveyed. In addition, as the core holes are drilled and new data are obtained, they will be incorporated into existing structural and isopach control to monitor the entire program from beginning to end. Each succeeding core hole's prognosis may be modified as required contingent upon data obtained in each preceeding core hole. Total depths of the two core holes located in grabens on Enclosure 2 may be modified considerably because the amount of fault displacement is somewhat questionable. In these core holes, the depth at which the Blue marker is encountered will control their depths. In all 15 core holes, total depth will be about 250 feet below the Blue marker, sufficient to identify the Orange marker on mechanical logs.

CORE HOLE		DATUM	DEPTH
1	Surface elevation	7200	0
	Middle A-groove	6900	300
	Blue marker	6025	1175
	Orange marker, TD	5775	1425
2	Surface elevation	7025	0
	Middle A-groove	6625	395
	Blue marker	5725	1295
	Orange marker, TD	5475	1545
3	Surface elevation	6900	0
	Middle A-groove	6475	425
	Blue marker	5550	1350
	Orange marker, TD	5300	1600
4	Surface elevation	7120	0
	Middle A-groove	6250	870
	Blue marker	5290	1830
	Orange marker, TD	5040	2080

CORE HOLE		DATUM	DEPTH
5	Surface elevation	6840	0
	Middle A-groove	6300	540
	Blue marker	5350	1490
	Orange marker, TD	5100	1740
6	Surface elevation	6680	0
	Middle A-groove	6200	480
	Blue marker	5225	1455
	Orange marker, TD	4975	1705
7	Surface elevation	7020	0
	Middle A-groove	6935	85
	Blue marker	6085	935
	Orange marker, TD	5820	1200
8	Surface elevation	7210	0
	Middle A-groove	6800	410
	Blue marker	5925	1285
	Orange marker, TD	5675	1535
9	Surface elevation	7160	0
	Middle A-groove	6600	560
	Blue marker	5700	1460
	Orange marker, TD	5450	1710
10	Surface elevation	7010	0
	Middle A-groove	6320	690
	Blue marker	5380	1630
	Orange marker, TD	5130	1880
11	Surface elevation	7340	0
	Middle A-groove	6550	790
	Blue marker	5680	1660
	Orange marker, TD	5430	1910
12	Surface elevation	7260	0
	Middle A-groove	6500	760
	Blue marker	5625	1635
	Orange marker, TD	5375	1885
13	Surface elevation	7200	0
	Middle A-groove	6570	630
	Blue marker	5680	1520
	Orange marker, TD	5430	1770
14	Surface elevation	7080	0
	Middle A-groove	6475	605
	Blue marker	5570	1510
	Orange marker, TD	5320	1760

CORE HOLE		DATUM	DEPTH
15	Surface elevation	6970	0
	Middle A-groove	6310	660
	Blue marker	5410	1560
	Orange marker, TD	5160	1810

The 15 core holes total approximately 25,550 feet of hole. Continuous coring will begin in each hole as soon as competent bedrock is encountered and end at total depth to obtain core data on overburden characteristics as well as the entire oil shale sequence down to the Orange marker. Oil yield assays will be run at 2-foot increments starting 100 feet above the A-groove and ending at the Orange marker, total depth. A total of about 18,850 feet of core will be assayed. Extractable alumina and trace element analyses will be run on about eight selected core holes spaced across the tract (See Section 5.3.5).

D.3 DRILLING METHOD

A contractor is being selected and the exact equipment description and details are not yet available. However, bid specifications call for drilling units capable of drilling to a depth of approximately 2,000 feet. A National T-20 rig with a 97-foot Lee C. Moore telescoping derrick would serve as an example of the type of unit called for. At least three rigs would be operating concurrently, each completing one core hole in an average of 14 days. Anticipated commencement date for the program is June 1, 1974.

The drilling fluid will be air-mist. Air-mist provides the best information for hydrologic testing while minimizing chance for formation of a downhole explosive mixture.

Two skid-mounted air compressors and one booster per rig will be used to furnish the air supply. Gardner-Denver models WEN and RL diesel-driven piston are the types of compressor units envisioned. Together, the two compressors would be capable of delivering 1,800 scf/min at a pressure of 200 psi. The booster (Gardner-Denver model RL) is a diesel-driven piston-type booster compressor capable of increasing the air delivery and pressure to 1,000 psi.

In the event it becomes necessary to convert to water or mud as the drilling fluid, a conventional rig mud pump will be available. This unit will be used to inject water into the airstream during air-mist drilling.

An automatically operated blowout preventer will be installed. This unit will either be a Hydril-type unit or a set of blind and pipe rams.

D.4 DRILLING PROGNOSIS

(a) Pick up 6 3/4-inch X 3 1/2-inch core head and core barrel, core approximately 150 feet. Ream hole to 11 inches and run about 150 feet 8 5/8-inch or 7-inch surface casing.

(b) Install casinghead flange, blowout preventer and rotating head. Test blowout preventer and casing to 750 psi. Install blooie and relief lines.

(c) Drill out cement and casing shoe with 6 3/4-inch bit using water. Convert to air-mist, go into hole with core barrel and obtain continuous core of entire interval to total depth as described under "Core Hole Information." All core

will be obtained with air-mist if practical. Foaming agents will be utilized as necessary.

(d) At total depth, all core holes will be logged as follows from TD to surface casing:

(1) Induction electric

(2) Compensated formation density with caliper

(3) Gamma-ray sonic with caliper (perhaps with variable density display contingent upon a logging expert's evaluation of oil shale logging now in progress)

(4) Engineered Production log (flowmeter-temperature)

(5) Neutron log

(6) Borehole televiewer (to be tested on one hole initially)

(e) Three holes will be abandoned as directed by the Mining Supervisor and 12 will be retained open to obtain additional ground water data.

(f) A geologist will be on location to describe all core with particular attention to fractures, joints, occurrence of nahcolite and natural bed partings; the last being important to future selection of potential roofstone in underground mines. He will also be responsible for supervising core packaging for shipment to an analytical laboratory.

(g) Gas samples will be taken at the A-groove, B-groove and total depth and analyzed for hydrocarbons, CO_2 and H_2S. Should gas be detected in the drilling fluid at any other time, a sample will be collected and analyzed.

D.5 HYDROLOGIC TESTING

As shown on Enclosure 2, several of the core holes will be used for hydrologic testing described in another section of the Exploratory Plan.

D.6 ACCESS

Gulf-Standard will arrange for surveying and staking of each drill site. Tentative access roads are shown on Enclosure 4. Federal representatives will be invited to visit each location with Gulf-Standard personnel and an earthwork contractor for federal approval or modification of each site, its preparation and its access road.

A minimum surface area will be disturbed. Topography will be utilized and the specific drill sites and access roads selected to harmonize with the existing landscape. Existing roads will be used as much as possible.

Additional roadwork will be required for some locations. A minor amount of brush clearing will be needed for access. All such work will be closely supervised to assure it is completed with minimum disturbance to vegetation and topography.

D.7 DAMAGE TO IMPROVEMENTS OTHER THAN ROADS

No damage to fences, gates, water structures, etc., is anticipated. Where it occurs, it will be repaired as quickly as possible or appropriately compensated for. Survey monuments, public or private, will be protected. However, if one is accidentally damaged or obliterated, the federal or other injured party will be compensated for its restoration.

D.8 HOUSING

Drilling crews will be transported daily to and from the tract. Emergency housing will be provided in the first-aid trailer (see Section 10.0 for description of these facilities).

Self-contained trailers will be used from time to time in the field as required by the drilling superintendent, geologist and hydrologist who supervise these activities. These will be removed when the core hole program is completed.

Permanent housing and services related to community or urban development will not be required because all of the employment is transient in nature.

D.9 WATER-POLLUTION CONTROL

As previously noted, air-mist is the planned drilling fluid. Should water flows be encountered in large quantities, it will be impounded and either be allowed to evaporate or be disposed of as recommended by the Mining Supervisor. Should the quantity of water be too great to continue drilling with air-mist, the prognosis calls for converting to mud or water as the drilling fluid. In this case, there will be on-site tankage for storing drilling fluids. In the event mud is used, it will be disposed of upon completion of the hole as directed by the Mining Supervisor.

The Water Quality Standards for Colorado and any other regulations of the Colorado Water Pollution Control Commission will govern actions at the drill sites. Contaminants or pollutants will be controlled and prevented from entering water sources or supplies. Privately owned water will

not be used without the written consent of the owner. Appropriate federal and state agencies will be kept informed on water quantities that the holes produce during drilling.

No equipment or part of the operation will be within 75 feet of a stream channel other than at crossings. Mud pits and pits used for hydrologic testing will be placed and operated to assure that the adjacent stream bed will not be polluted.

D.10 SAFETY OF PUBLIC AND LIVESTOCK

The drill hole, excavations and improvements shall be conditioned at all times to prevent injury to persons, livestock and wildlife. All operations shall be conducted in a safe workmanlike manner. The general area surrounding the operations shall be available to the public for uses including, but not limited to, livestock grazing, hunting, fishing, camping, hiking and picnicking, except where such uses may be unsafe to the user. Livestock will not be unnecessarily disturbed.

D.11 VEGETATION AND WILDLIFE

Disturbance of vegetation shall be kept to a minimum. Habitat disturbance will be kept to as small an area as possible. Very little vegetation of commercial value beyond grazing land occurs in the area; but where products of commercial value, such as posts, poles, firewood, stone or sand must be removed, the Mining Supervisor's attention will be directed to it in order for him to direct the disposition thereof. Areas stripped of vegetation, such as drill sites, will upon completion of the program be reseeded and the desirable vegetation re-established. The kind

and quantity of seed used and time of seeding will be at the direction of the Mining Supervisor.

D.12 SOLID WASTE DISPOSAL

A core program utilizing air-mist generates very small quantities of solid wastes. These will be disposed of at the well site pit. Oil cans, lunch sacks, filters, cement sacks and such will be buried in a designated pit or removed from the site and disposed of at an existing sanitary fill. Open burning will not be done without first securing a permit.

D.13 ANTIQUITIES AND FOSSILS

If in the course of the program anything is found that is suspected of being an object of scientific or historic interest, such as a prehistoric ruin, megafossil or artifact, no further activity that might damage it will be undertaken and the Mining Supervisor will be notified immediately.

D.14 OTHER

There is no foreseeable reason why explosives would be used in the core hole program. Before ordering any explosives, an application for a permit to store and handle explosives would be submitted to the Colorado Bureau of Mines.

No operations will be conducted which would interfere with the orderly development and production of existing oil and gas leases covering the same lands.

In the event a potable water aquifer is penetrated, the Mining Supervisor will be notified.

If questions arise relative to surface control or drilling, the Mining Supervisor will be consulted immediately. All federal and state laws, regulations and standards relating to air, water, land and noise pollution will be obeyed. All operations will comply with applicable federal and state mine safety laws, regulations and standards.

All operations will be coordinated with and reported to the office of the Mining Supervisor.

For Gulf-Standard (Indiana)

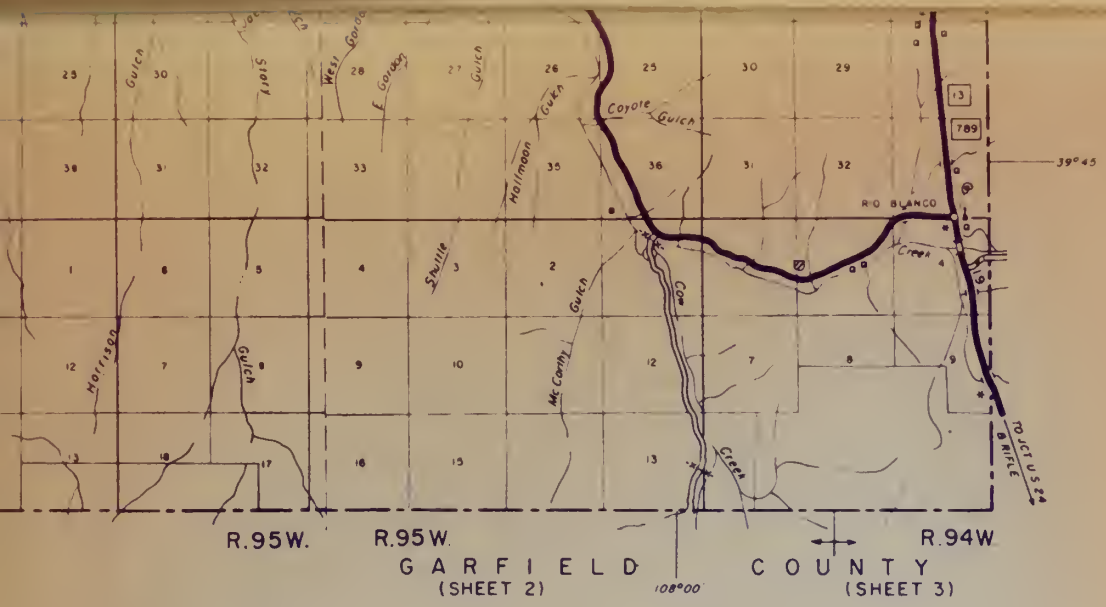
By Eugene A. Ziemba

Date May 1, 1974

Drilling and Operating Plan Approved

By_____

Date_____



GULF-STANDARD (INDIANA)

ENCLOSURES

1 REGIONAL MAP

2 PRELIMINARY A-GROOVE STRUCTURE AND TOPOGRAPHIC BASE MAP

3 SW-NE HISTOGRAM CROSS-SECTION AND MAIN OIL SHALE INTERVAL ISOPACH MAP

4 SUPPORT ROADS AND FACILITIES


MOFFAT COUNTY MOFFAT
(SHEET 3)
R.104W. R.103W. R.102W. R.101W. R.100W. R.99W. R.98W. R.97W.
T.3N. T.2N. T.1N. T1S T.2S. T.3S
RAVEN PARK BASIN
RAVEN RIDGE
RANGELY
YELLOW CRK. DAM SITE
DUCK CRK. DAM SITE
TRACT & VICINITY
FED. TRACT C-a
BASE LINE
UINTAH COUNTY
RABBIT HILLS
THE BOOK CLIFFS

C O U N T Y M O F F A T (SHEET 3) C O U N T Y M O F F A T (SHEET 4)

R.100W. R.99W. R.98W. R.97W. R.96W. R.95W. R.94W.

YELLOW CRK. DAM SITE

DUCK CRK. DAM SITE

TRACT & VICINITY

FED. TRACT C-a

RIO BLANCO RES. STATE RECREATION AREA

MEEKER

MEEKER POP. 1,597

COLORADO MOUNTAIN

DANFORTH HILLS

Sixth Principal Meridian

BASE LINE

T.3S.

TRACT & VICINITY

FED. TRACT C-a

T.2S.

T.3S.

T.4S.

R.104W.

R.103W.

R.102W.

R.101W.

R.100W.

R.99W.

R.98W.

R.97W.

(SHEET 2)

(SHEET 1)

G A R F I E L D C O U N T Y

U T A H

PROPOSED PROGRAM

OVERFLIGHT AREA FOR COLOR AND COLOR-INFRARED AERIAL PHOTOGRAPHY. (APPROX 380 SQ MI.)

AREAS (3) FOR:
PHOTOGEOLOGIC MAPPING
SURFACE GEOLOGIC MAPPING
DETAILED TOPOGRAPHIC MAPPING
(APPROX. 85 SQ. MI.)

NOTE:
SEE ENCL. NO. 4 FOR SUPPORT ROADS.

KEY TO COUNTY SHEETS

SHEET 1 · SHEET 2 · SHEET 3 · SHEET 4

MODIFIED POLYCONIC PROJECTION

GENERAL LEGEND

GENERAL HIGHWAY MAP

RIO BLANCO COUNTY COLORADO

PREPARED BY THE
STATE DEPARTMENT OF HIGHWAYS
DIVISION OF HIGHWAYS - STATE OF COLORADO
PLANNING AND RESEARCH DIVISION
IN COOPERATION WITH THE
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

SCALE OF MILES

1961

STATE HIGHWAY SYSTEM REVISED AS OF JAN 1, 1972
COUNTY ROAD SYSTEM REVISED AS OF JAN 1, 1972

SHEET 1 OF 4 SHEETS

TRACT & VICINITY

FED. TRACT C-a

T. 3 S.

R.100W. R.99W. R.98W. R.97W. R.96W. R.95W. R.94W.

(SHEET 1) C O U N T Y (SHEET 2) G A R F I E L D C O U N T Y (SHEET 3)

PROPOSED PROGRAM

OVERFLIGHT AREA FOR
COLOR AND COLOR-INFRARED
AERIAL PHOTOGRAPHY. (APPROX 380 SQ MI.)

AREAS (3) FOR:
PHOTOGEOLOGIC MAPPING
SURFACE GEOLOGIC MAPPING
DETAILED TOPOGRAPHIC MAPPING
(APPROX. 85 SQ. MI.)

NOTE:
SEE ENCL. NO. 4 FOR SUPPORT ROADS.

BEET DUMP
STOCK YARD - LOADING PEN
MILITARY RESERVATION OR PORT
HISTORIC RUIN
CAMP GROUND (NO BUILDINGS)
TOURIST COURT OR MOTEL
CAMP OR LODGE
RANGER STATION
RANGER STATION (NOT PERMANENTLY OCCUPIED)
LOOKOUT STATION
TRIANGULATION STATION
GATE HOUSE OR TOLL HOUSE
DRIVE-IN THEATRE
SKI TOW
GOLF COURSE, COUNTRY CLUB
ATHLETIC FIELD
SMALL PARKS (SP-STATE, CP-COUNTY, MP-MUNICIPAL, WP-WAYSIDE PARK)
FAIRGROUNDS, SPEEDWAYS, AND RACE COURSES
STATE CAPITAL
COUNTY SEAT
OTHER CITIES AND VILLAGES
CULTURAL FEATURES SHOWN OUT OF POSITION
DETAIL MAPS SHOWN THUS
SUBURBAN AREAS SHOWN ON SUPPLEMENTAL MAP SHEET 3

GENERAL HIGHWAY MAP

RIO BLANCO COUNTY
COLORADO

PREPARED BY THE
STATE DEPARTMENT OF HIGHWAYS
DIVISION OF HIGHWAYS - STATE OF COLORADO
PLANNING AND RESEARCH DIVISION
IN COOPERATION WITH THE
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

SCALE OF MILES
0 1/2 1 2 3 4

1961
STATE HIGHWAY SYSTEM REVISED AS OF JAN 1, 1972
COUNTY ROAD SYSTEM REVISED AS OF JAN 1, 1972

GULF-STANDARD (INDIANA) EXPLORATORY PLAN

FED. TRACT C-a
(OIL SHALE)

RIO BLANCO COUNTY, COLORADO

REGIONAL MAP

COMPOSITE OF SHEETS 1, 2 & 3 OF
STATE DEPT. OF HIGHWAY MAPS

SCALE: 1"=2 MILES

ENCL. NO. 1


R 100 W
R 99 W
T
S
EXXON
EXXON
CE 706
CE 704-C Not Cored
USBM
STATE WILD LIFE
MINTECH
MIN TECH (UNPAT.)
ERTL
ERTL
SHELL 44-X-27
SHELL 11-X-1
+7000
+6800
+6600
+6400
+6200
+6000
STATE WILD LIFE
STATE WILD LIFE
SHIELD CALDWELL HUNTING CLUB
TOSCO
OCCIDENTAL
CARTER
WILD LIFE
CE 707 +6767
CE 708 +6779
CE 701 +6785
+6795 TOSCO
CE 702
+6097
CE 703 +6934.2
+6475 TOSCO +6475
705-A
CATHEDRAL
CATHEDRAL
BLUFFS
DEAD HORSE RIDGE
SAGEBRUSH HILL

R 99 W

R 98 W

EXXON

EXXON

EXXON

WILD LIFE

USBM

CE 704-C Not Cored

WOLF RIDGE

SINCLAIR

WOLF RIDGE

OROCO

STATE WILD LIFE

STATE WILD LIFE

BELL & STATE WILD LIFE

BELL & STATE WILD LIFE

CARTER

SHIELD CALDWELL HUNTING CLUB

HUMBLE Partly Cored

JUHAN

+6800

+6600

+6400

+6200

+6000

T 1 S

SHELL
11-X-1

ERTL

SHELL
42-X-10

ERTL
(UNPAT.)

ERTL

SHELL
32-X-7

A-GROOVE BEHIND
SURFACE PIPE

+7000

+6800

+6600

+6400

+6200

SHIELD
CALDWELL
HUNTING CLUB

CE M +6767
707

CE M +6779
708

CE M +6934
703
Not
Cored

CE +6501

+6475 M
CE TOSCO
+6475
705-A

MUNSON
+6834

AMOCO M +6737
3

BRITISH-
AMERICAN

AMOCO
+6369
4

AMOCO M +6433
2-A

VANDERBILT
MUNSON
+6501

BELL & STATE
WILD LIFE

EQUITY

GARRETT

MOBIL & EQUITY

WEBER

AMER
MINERALS

EQUITY

TOSCO

T 2 S

T 3 S

R 100 W

39°52'30"

A - GROOVE BEHIND SURFACE PIPE

SHIELD ② CALDWELL HUNTING CLUB

CE M +6767 707

CE M +6779 708

CE +6934.2 703 Not Cored

+6475 CE M TOSCO +6475 705-A P

MUNSON +6834

SHELL 32-X-7

AMOCO M +6737 3

BRITISH-AMERICAN

AMOCO +6369 4

AMOCO M +6433 2-A

VANDERBILT MUNSON +6501

+6800

+6600

+6400

+6200

CARTER

BELL & STATE WILD LIFE

GARRETT

EQUITY

FAULTS MAPPED BY USGS MISC. FIELD STUDIES MAP MF-309 Austin, 1971

REIGLE RANCH

TOSCO

AMER MINERALS

WEBER

HUMBLE Partly Cored

JUHAN 4-1

PAN AMERICAN

GREAT YELLOWSTONE

HUBER

HYLAND

EXXON ARCO EQUITY

Wolf Ridge

Stake Springs

Maverick Spring

Draw

Gulch

Ryan Gulch

Gallaway Gulch

Right Fork Stake Springs Draw

Left Fork Stake Springs Draw

Black Cabin Point Gulch

RIDGE

PIPELINE

T 2 S

T 3 S

Mapped, edited, and published by the Geological Survey
Control by USGS and USC&GS
Topography from aerial photographs by multiplex methods
Aerial photographs taken 1948. Field check 1952
Polyconic projection. 1927 North American datum
10,000-foot grid based on Colorado coordinate system, north zone
1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue

UTM GRID AND 1952 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 20 & 40 FEET
DATUM IS MEAN SEA LEVEL

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225 OR WASHINGTON, D. C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

COLORADO
QUADRANGLE LOCATION

ROAD CLASSIFICATION
Light-duty
Unimproved dirt

LEGEND

- COREHOLE
- DRY HOLE
- GAS WELL
- FED. TRACT C-a
- +6475 DATUM MIDDLE A-GROOVE
- ANTICLINAL AXIS
- OBSERVED SURFACE FAULT; U/D
- PROJECTED FAULT

NOTES:

COMPOSITE MAP OF USGS 7.5 MIN. QUADS
SAGEBRUSH HILL
WOLF RIDGE
BLACK CABIN GULCH (PARTIAL)
YANKEE GULCH (PARTIAL)

LAND DATA

① SURFACE ONLY

② SURFACE PLUS UNRESERVED MINERALS*

③ UNPATENTED OIL SHALE CLAIMS

* UNRESERVED MINERALS - ALL MINERALS OTHER THAN OIL SHALE, OIL AND GAS OR OTHER ROCKS VALUABLE AS A SOURCE OF PETROLEUM AND NITROGEN. UNRESERVED MINERALS INCLUDE DAWSONITE AND NAHCOLITE.

PROPOSED PROGRAM (May, 1974)

1. DRILLING (GEOLOGIC & HYDROLOGIC)
   - 1-15 COREHOLE (15 TOTAL)
   - 16 (D) DRILLED HOLE ON TRACT FOR HYDROLOGIC TESTING.
   - 1-4 (M) M M UPPER AND LOWER AQUIFER MONITOR HOLES
   - (P) PUMP TEST HOLE
   - 1-12 (S) SHALLOW HOLE FOR ALLUVIUM WATER MONITORING
2. PHOTOGEOLOGIC MAPPING
3. SURFACE GEOLOGIC MAPPING
4. DETAILED TOPOGRAPHIC MAPPING (Same area shown on Encl. No. 1 as Tract and Vicinity)
5. SEISMIC LINES ON EXISTING ROADS
6. SURFACE WATER GAUGING STATION (W)

REVISION 1

DRILLING PRO

ORIGINAL

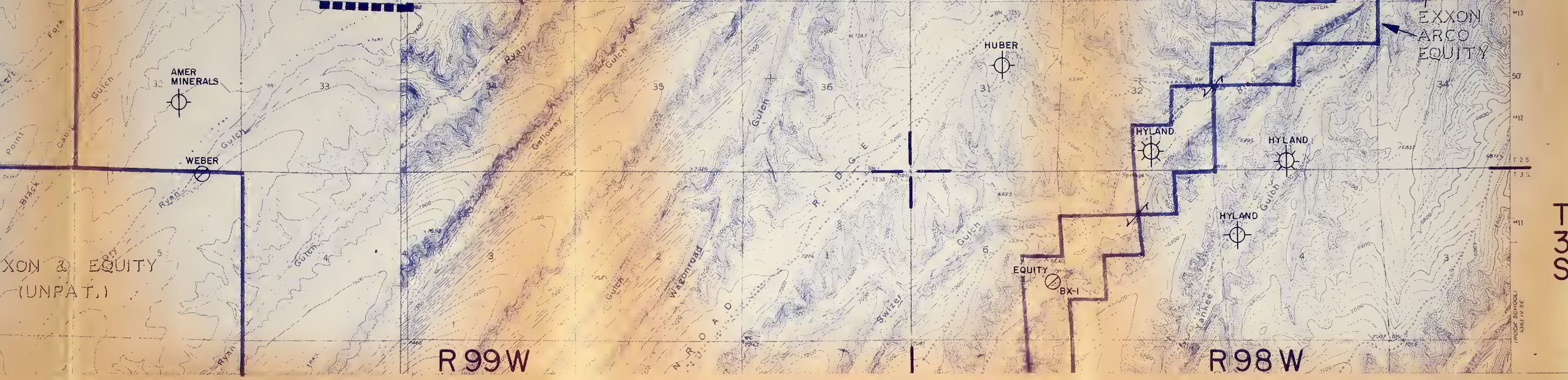
REVISED

HOLES AFFEC

COREHOLE
BY COREH
M-1
S-5 and

REVISION 2

M-4 ADDED
ROAD CHANGE



1 MILE

ROAD CLASSIFICATION
1964
Light-duty ——— Unimproved dirt - - - - - -

COLORADO
QUADRANGLE LOCATION

D. C 20242

PROPOSED PROGRAM (May, 1974)

1. DRILLING (GEOLOGIC & HYDROLOGIC)
   - (1-15) COREHOLE (15 TOTAL)
   - (D 16) DRILLED HOLE ON TRACT FOR HYDROLOGIC TESTING.
   - (1-4 M) (M) UPPER AND LOWER AQUIFER MONITOR HOLES
   - (P) PUMP TEST HOLE
   - (S 1-12) SHALLOW HOLE FOR ALLUVIUM WATER MONITORING
2. PHOTOGEOLOGIC MAPPING
3. SURFACE GEOLOGIC MAPPING
4. DETAILED TOPOGRAPHIC MAPPING
   (Same area shown on Encl. No. 1 as Tract and Vicinity)
5. SEISMIC LINES ON EXISTING ROADS
6. SURFACE WATER GAUGING STATION (W)

REVISION 1 (June, 1974)

DRILLING PROGRAM

ORIGINAL LOCATION
REVISED LOCATION

HOLES AFFECTED

COREHOLES 2,3,4 and 5 REPLACED
BY COREHOLES 2-3 and 4-5
M-1
S-5 and 11

REVISION 2 (July, 1974)

M-4 ADDED
ROAD CHANGED ON EAST SIDE OF TRACT.

GULF-STANDARD (INDIANA) EXPLORATORY PLAN

FED. TRACT C-a

(OIL SHALE)

RIO BLANCO COUNTY, COLORADO

PRELIMINARY A-GROOVE STRUCTURE AND TOPOGRAPHIC BASE MAP

REVISION 2
JULY, 1974

TOPO C I = 20 & 40'
STRUCTURE C I = 200'
SCALE 1" = 2000'

ENCL. NO. 2

10 - 9 - 74

A — A′

SW — NE

AMOCO	CAMERON	CAMERON
3	705-A	702
1038' FEL-1750' FNL	97' FEL-2108' FNL	868' FEL-1621' FNL
8-T2S-R99W	4-T2S-R99W	34-T1S-R99W
6931 KB	6745 KB	6667 KB
1345 TD	1550 TD	1808 TD
10-10-73	12-10-71	8-29-72

7700' (1.5 Miles) — 7400' (1.4 Miles)

U.S.G.S. OIL SHALE ZONATION; OIL & GAS INVESTIGATIONS CHART OC-65; CASHION & DONNELL, 1972

GAL/TON OIL YIELD HISTOGRAM
25 G/T
0 10 20 30 40 50 60 70 80

DUAL INDUCTION-LATEROLOG OF CAMERON 702 CH.

DATUM

194(+6737) — 270 (+6475) — 562 (+6105) MIDDLE A-GROOVE

593 MAHOGANY MARKER (LITHOLOGIC MARKER BEO)

720 MIDDLE B-GROOVE

MAHOGANY

MAHOGANY "RICH"

220 — 295 — 331 — 412

R-6

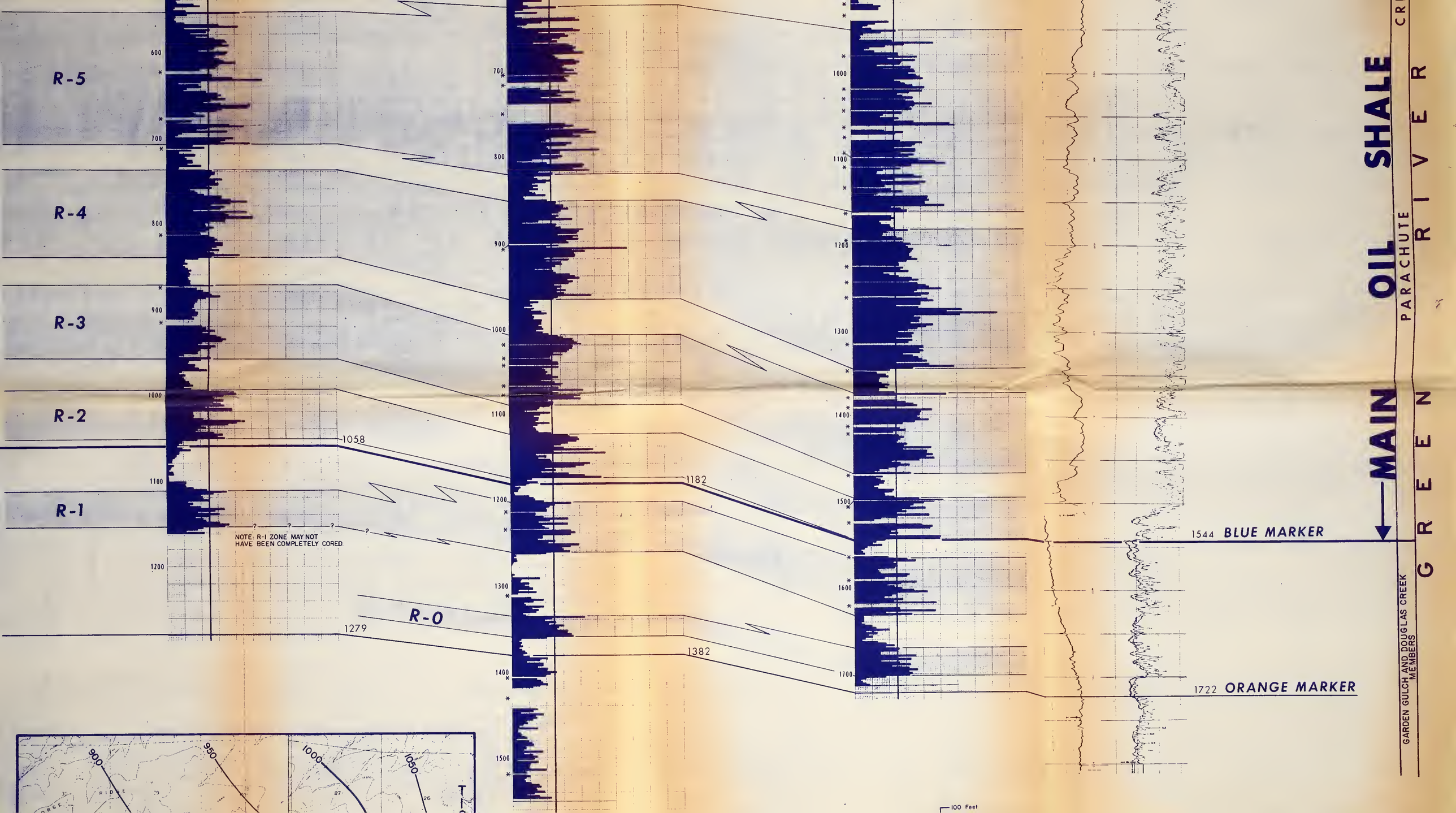
R-5

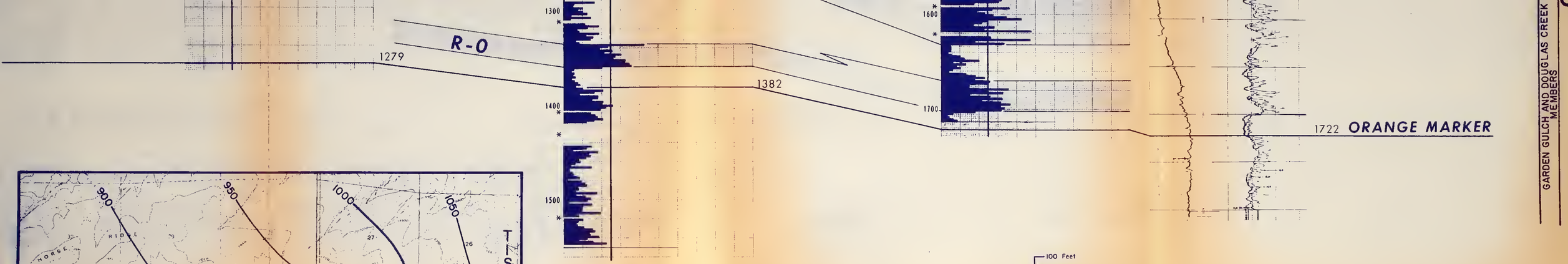
R-4

200 300 400 500 600 700 800 900 1000 1100

SHALE INTERVAL — MEMBER — FORMATION

CREEK — RIVER


R-5
R-4
R-3
R-2
R-1
R-0
1058
1182
1279
1382
NOTE: R-1 ZONE MAY NOT HAVE BEEN COMPLETELY CORED.
1544 BLUE MARKER
1722 ORANGE MARKER
MAIN OIL SHALE
PARACHUTE CREEK MEMBER
GREEN RIVER
GARDEN GULCH AND DOUGLAS CREEK MEMBERS
100 Feet
900
950
1000
1050

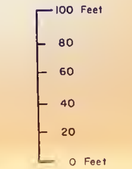


NOTE:

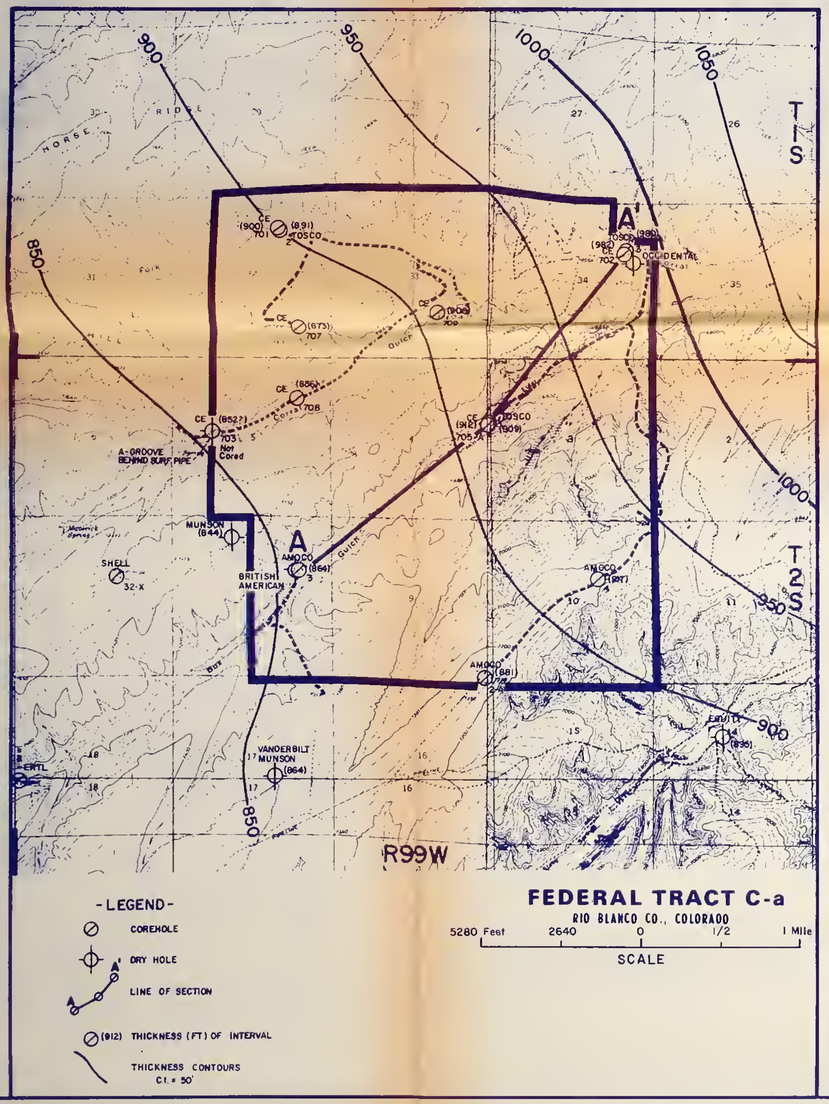
TOPS AND BASES OF RICH SHALE ZONES ARBITRARILY DEFINED BY 25+ G/T SHALE.

ASSAYS BY U.S.B.M., LARAMIE, WYOMING.

* MISSING CORE INTERVAL



VERTICAL SCALE



-LEGEND-

- COREHOLE
- DRY HOLE
- LINE OF SECTION
- (912) THICKNESS (FT) OF INTERVAL
- THICKNESS CONTOURS C.I. = 50'

FEDERAL TRACT C-a

RIO BLANCO CO., COLORADO

5280 Feet 2640 0 1/2 1 Mile

SCALE

GULF-STANDARD (INDIANA) EXPLORATORY PLAN

FED. TRACT C-a

(OIL SHALE)

RIO BLANCO COUNTY, COLORADO

SW-NE HISTOGRAM CROSS-SECTION

(APPROX. NORMAL TO ISOPACH STRIKE)

AND

MAIN OIL SHALE INTERVAL ISOPACH MAP C.I. 50'

HORIZONTAL SCALE: NONE

ENCL. NO. 3

RANGELY
CURRENT
POPULATION 1591

FACILITY	CAPACITY	CURRENT % USED
WATER TREATMENT	1900 PEOPLE	84 %
SEWER TREATMENT	3200 PEOPLE	50 %
SCHOOL	1100 PUPILS	58 %
HOSPITAL	28 BEDS	17 %

R. 102 W. R. 101 W. R. 100 W. R. 99 W. R. 98 W. R. 97 W R. 96 W. R 95

T 1 N

T 2 N

T 1 S

T 2 S

WHITE RIVER

Rangely

COLORADO MT. N

EXISTING

CALAMITY RIDGE

PROPOSED ROAD BLM PROJ. 110 SEC 3.

PRIVATE PROPERTY

COLORADO STATE LANDS

PROVIDE CATTLE GUARDS AT EXISTING FENCES AS REQUIRED

TRACT C-a

Ⓐ SURFACING OF SPENT SHALE AND/OR CRUSHED SITE MATERIALS WHERE REQUIED AS DETERMINED IN THE FIELD

COLORADO STATE LANDS

PRIVATE PROPERTY

WHITE RIVER ELECTRIC CO 73 KV POWER LINE

16'-0" ℄ ROADWAY 12'-0" — CLEARED — 6" SURFACING

CULVERTS & TURNOUTS PROVIDED WHERE NEEDED TYP SECTION /4 TO 6

RANGELY 1 2 3 4 5 6

8,000 7,000

RANGELY 10.8 MILES STATE HIGHWAY 64 RIO BLANCO CO

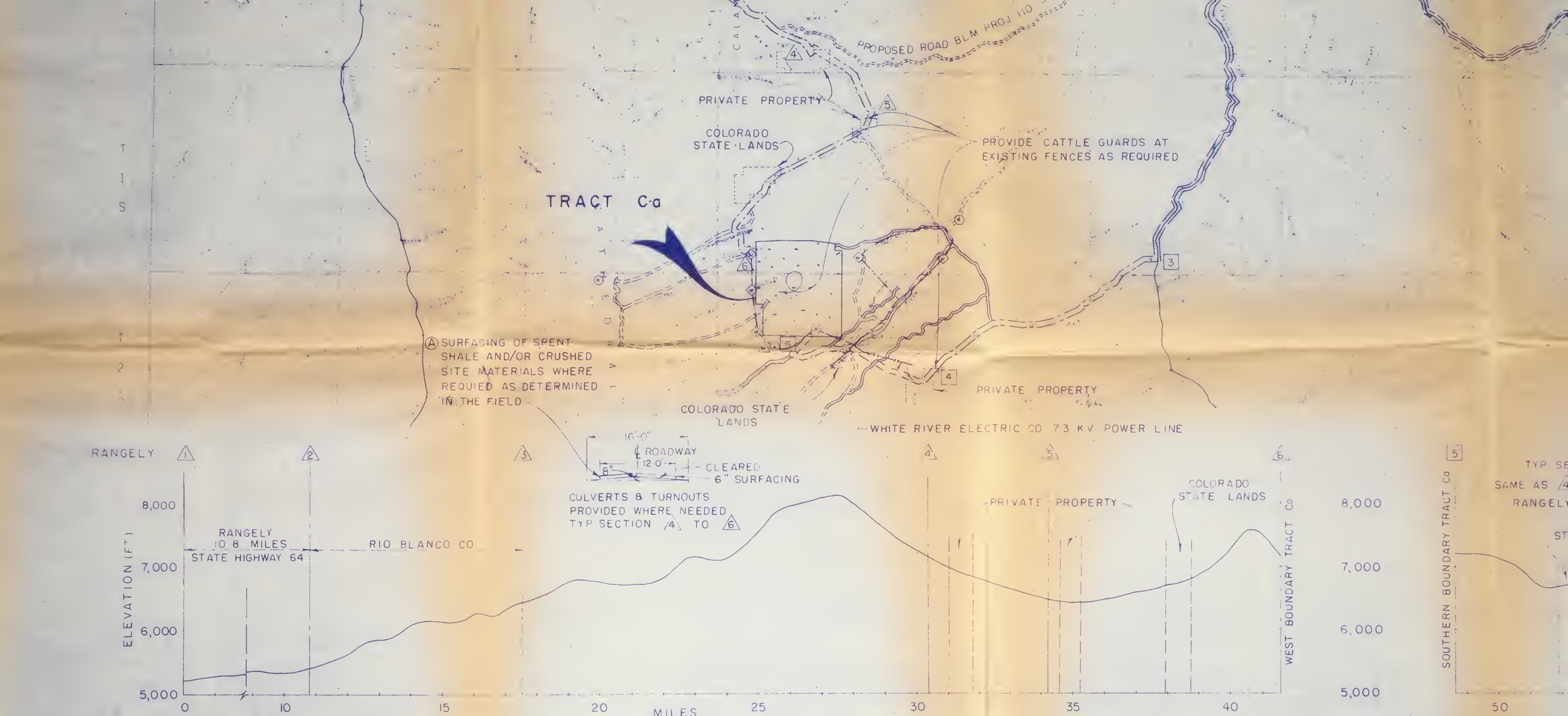
PRIVATE PROPERTY

COLORADO STATE LANDS

BOUNDARY TRACT C-a

TYP SE SAME AS 4 RANGELY

ST



ACCESS FROM WEST (RANGELY)

FEATURE OR DESCRIPTION	1	2	3	4	5	6	DRILL HOLE ACCESS ROADS — SEE DETAILS ABOVE UNDER TYPICAL SECTION & REMARKS
PHYSICAL DATA							
LENGTH	10.8 MILES	6.7 MILES	12.9 MILES	3.8 MILES	7.4 MILES		
WIDTH	—	16'-0"	16'-0"	16'-0"	16'-0"		
SURFACING	TWO LANES PAVED	GRAVELED	IMPROVED DIRT	IMPROVED DIRT	IMPROVED DIRT		
CONSTRUCTION	COMPLETED	BUILT IN 1965	BUILT IN 1971	—	—		
REMARKS	OPEN ALL SEASONS	COMPLETED	COMPLETED	NEW CONST.	NEW CONST		
ADMINISTRATIVE DATA				(LESSEE)	S.L.U.P. TRAM PERMIT,		
RESPONSIBILITY (FUNDING)	STATE HWY DEP'T	RIO BLANCO COUNTY	BUREAU OF LAND MANAGEMENT	GULF - STANDARD	GULF - STANDARD (LESSEE)		
PERMIT REQUIRED	N.A.	N.A.	N.A.	YES S.L.U.P.	YES S.L.U.P. YES		
CONSTRUCTION PLANS	N.A.	N.A.	N.A.	GULF - STANDARD	GULF - STANDARD (LESSEE)		
MAINTENANCE PLANS	N.A.	N.A.	GULF - STANDARD - (LESSEE)	GULF - STANDARD	GULF - STANDARD (LESSEE)		

R 95 W.

R 94 W

T 2 N

T 1 S

T 2 S

41 MILES
MEEKER TO RIFLE

Meeker

Rifle

MEEKER
CURRENT
POPULATION 1678

FACILITY	CAPACITY	CURRENT % USED
WATER TREATMENT	1900 PEOPLE	88%
SEWER TREATMENT	2000 PEOPLE	84%
SCHOOL	900 PUPILS	76%
HOSPITAL	20 BEDS	30%

RIFLE
CURRENT
POPULATION 2500

FACILITY	CAPACITY	CURRENT % USED
WATER TREATMENT	2700 PEOPLE	93%
SEWER TREATMENT	4500 PEOPLE	56%
SCHOOL	1520 PUPILS	93%
HOSPITAL	32 BEDS	40%

LEGEND

- STATE ROADS
- COUNTY ROADS
- B.L.M ROADS
- NEW CONST.

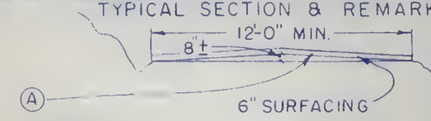
EXISTING & PROPOSED TEST HOLES

- EXISTING ROADS
- PROPOSED ROADS

NO SCALE

DRILL HOLE ACCESS ROADS (IN TRACT C-a)

TYPICAL SECTION & REMARKS



CLEARED AREA PASSABLE WITH DRILL RIG & SUPPLIES.

ROAD DESCRIPTION - MILES REQUIRED

EXISTING ROADS MEETING ABOVE TYPICAL SECTION WITH MINOR OR NO IMPROVMENTS	10.6
EXISTING JEEP ROADS REQUIRING MINOR IMPROVEMENTS TO MEET ABOVE TYPICAL SECTION	0.5
NEW ROADS TO-BE-BUILT TO MEET ABOVE TYPICAL SECTION	4.7
NEW ROADS TO-BE-BUILT FOR MINIMAL ACCESS NOT CLEARED AND NOT MEETING ABOVE TYPICAL SECTION	0.2

LEGEND

EXISTING	PROPOSED
COREHOLE	COREHOLE
DRY HOLE	DRILLED HOLE ON TRACT FOR HYDROLOGIC TESTING.
POWER LINE	PUMP TEST HOLE
	SHALLOW HOLE FOR ALLUVIUM WATER MONITERING
	SURFACE WATER GAGING STATION
	RAINFALL INTENSITY GAGING STATION
	FIRST AID STATION AND FIELD OFFICE
	METEOROLOGICAL STATION
	AIR QUALITY MONITORING STATION
	POWER LINE

NOTES

SLUP (SPECIAL LAND USE PERMIT) REQURIED FOR UPGRADING OF EXISTING BUREAU OF LAND MANAGEMENT ROADS.

TRACT C-a

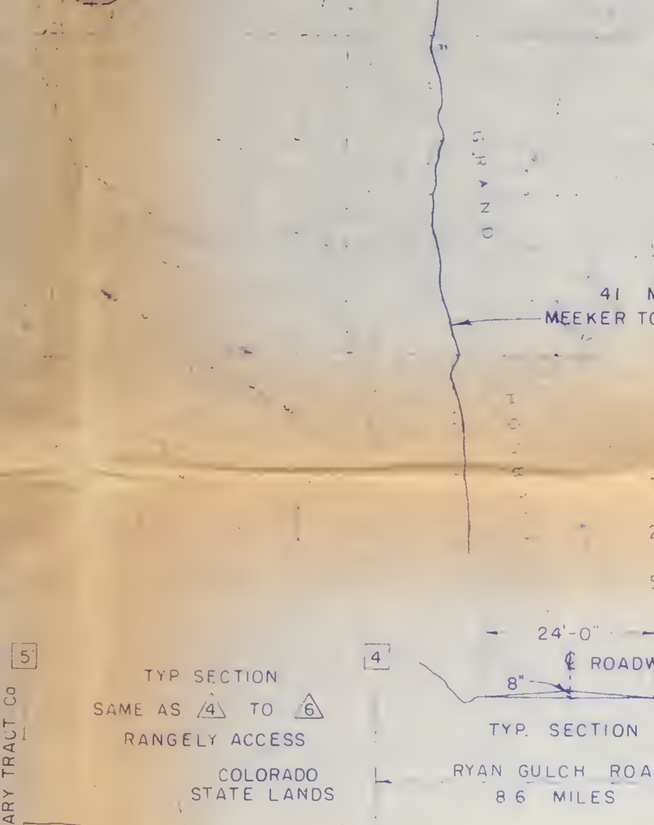
5 — TYP SECTION SAME AS 4 TO 6 RANGELY ACCESS COLORADO

4 — 24'-0" ℄ ROADWAY, 8" — TYP SECTION — RYAN GULCH ROAD

3

2 — PICEANCE CREEK ROAD

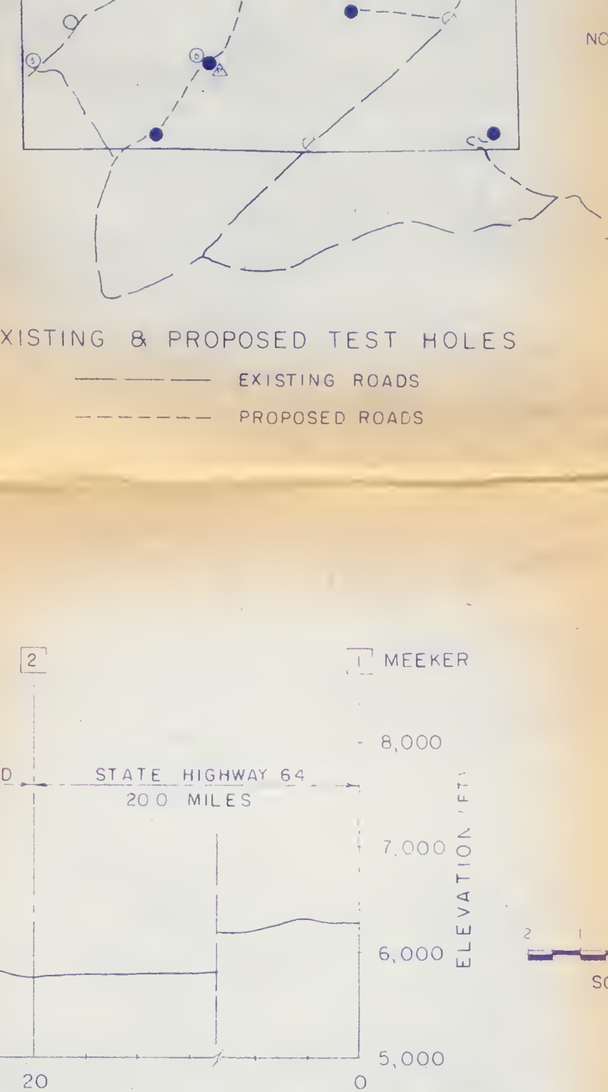
1 MEEKER — STATE HIGHWAY 64 — 8,000



RIFLE

CURRENT POPULATION 2500

FACILITY	CAPACITY	CURRENT % USED
WATER TREATMENT	2700 PEOPLE	93%
SEWER TREATMENT	4500 PEOPLE	56%
SCHOOL	1520 PUPILS	93%
HOSPITAL	32 BEDS	40%



EXISTING & PROPOSED TEST HOLES

EXISTING ROADS

PROPOSED ROADS

NO SCALE

LEGEND

EXISTING	PROPOSED
COREHOLE	COREHOLE
DRY HOLE	DRILLED HOLE ON TRACT FOR HYDROLOGIC TESTING.
POWER LINE	PUMP TEST HOLE
	SHALLOW HOLE FOR ALLUVIUM WATER MONITERING
	SURFACE WATER GAGING STATION
	RAINFALL INTENSITY GAGING STATION
	FIRST AID STATION AND FIELD OFFICE
	METEOROLOGICAL STATION
	AIR QUALITY MONITORING STATION
	POWER LINE

ACCESS FROM EAST (MEEKER)

6.7 MILES	8.6 MILES	16.1 MILES	20.0 MILES
16'-0" IMPROVED DIRT	24'-0" IMPROVED DIRT	TWO LANES PAVED	TWO LANES PAVED
NEW CONST	COMPLETED	COMPLETED OPEN ALL SEASONS	COMPLETED OPEN ALL SEASONS
GULF-STANDARD (LESSEE) SLUP YES	RIO BLANCO COUNTY SLUP YES	RIO BLANCO COUNTY N.A.	STATE HWY DEP'T N.A.
GULF-STANDARD (LESSEE)	N.A.	STATE UPGRADING PENDING N.A.	N.A.
GULF-STANDARD (LESSEE)	RIO BLANCO COUNTY		

SCALE 1" = 2 MILES

NOTES

SLUP (SPECIAL LAND USE PERMIT) REQURIED FOR UPGRADING OF EXISTING BUREAU OF LAND MANAGEMENT ROADS.

TRAM PERMIT (43 CFR 2810) REQUIRED FOR NEW ROAD CONSTRUCTION. SURFACING TO BE REQUIRED ON STEEP SLOPES AND/OR POOR DRAINAGE AREAS AS DETERMINED IN THE FIELD

AIR QUALITY MONITORING STATION Nº 4 WILL BE INITIALLY LOCATED AT THE EXPECTED POINT OF MAXIMUM CONCENTRATION; THE STATION SHALL BE MOBIL AND WILL MONITOR, AT INTERVALS, ON A REGULAR BASIS

GULF-STANDARD (INDIANA) EXPLORATORY PLAN

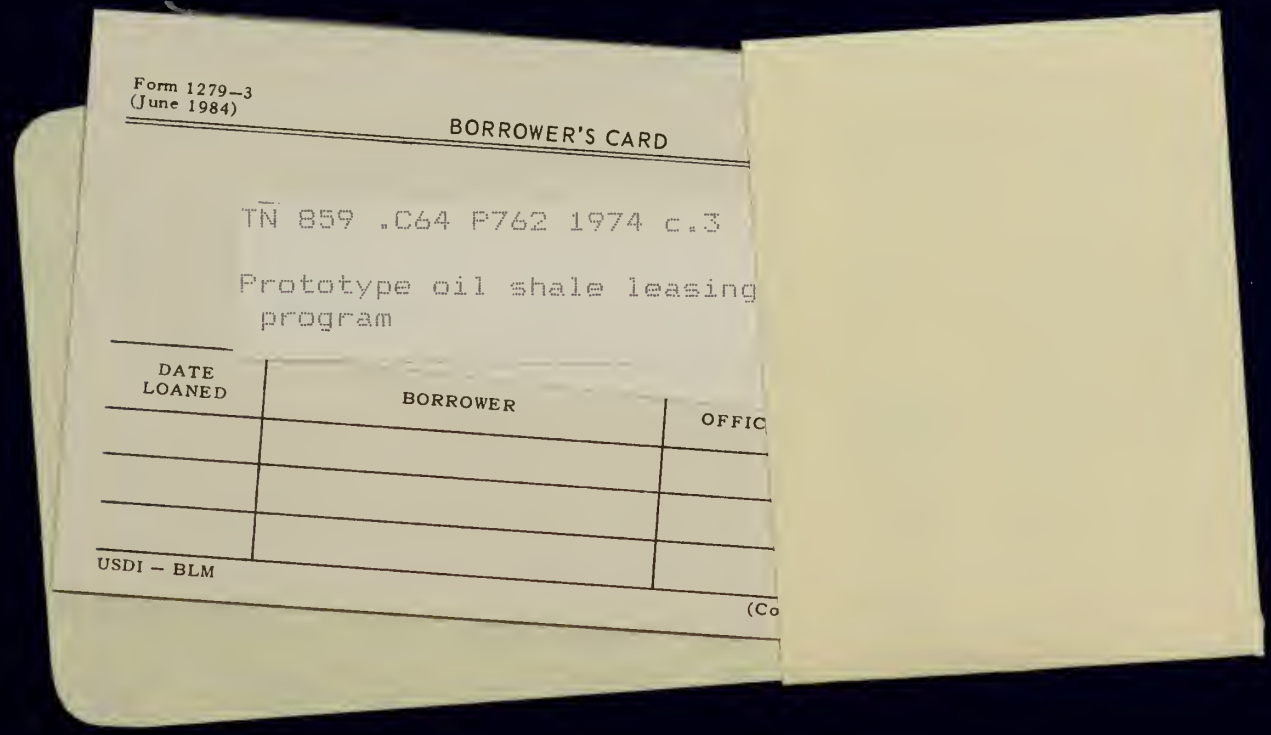
FED. TRACT C-a

OIL SHALE

RIO BLANCO COUNTY, COLORADO

SUPPORT ROADS AND FACILITIES

PREPARED WESTERN ENGINEERS, INC GRAND JCT., COLO. ENCL. NO. 4



Form 1279–3
(June 1984)

BORROWER'S CARD

TN 859 .C64 P762 1974 c.3

Prototype oil shale leasing program

DATE LOANED	BORROWER	OFFIC

USDI – BLM

(Co